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TWENTIETH CENTURY TROGLODITES—EXTERIOR OF A GROUP OF FRENCH CAVE DWELLINGS.—[SEE PAGE 130]

SCIENTIFIC AMERICAN MONTHLY

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ANNOUNCEMENT

Much as we regretted it, we were obliged last July to announce the suspension of the Scientific American Monthly for the months of August and September owing to the serious paper situation. We are glad to resume publication with the present issue and trust that there will be no further interruptions. Our readers will have their subscriptions extended for two months to make up for the missing issues.

We regret that we must announce at this time an increase in the subscription price of the Scientific American Monthly. This is a necessity imposed upon us by abnormal conditions in the publishing business. At present prices and under present conditions our publications can be produced only at considerable loss. Our manufacturing costs, barring the single item of paper, have increased 200 per cent; the cost of paper since the beginning of the war has increased 300 per cent, postage under the zone legislation has increased 200 per cent. Like most other publishers, we hesitated to take the drastic action necessary to meet these increases, until it had become entirely clear that it was a permanent rather than a temporary condition that faces us. Stabilization of business on a new basis has gone sufficiently far for us to be assured now that this higher level of costs will not be materially abated, at least for a long time. In company with conservative publishers everywhere, we therefore find it necessary now to readjust the selling price of our product to conform with the new conditions.

From this date the price of the Scientific American Monthly will be advanced from five to seven dollars, annual subscription, and from 50 to 60 cents per copy.

Despite the serious handicaps imposed upon the publisher we have endeavored to maintain the Scientific American Monthly at a high standard and hope to improve it still further in future issues. Suggestions and constructive criticism from our readers are welcomed.

LETTING LIGHT IN THROUGH THE EARS

An invention which gives promise of being quite the most remarkable so far developed by man and one which is of the utmost importance to the blind is the type-reading optophone. This marvelous instrument actually reads ordinary printed matter and it reads it aloud very slowly or comparatively rapidly according to the will of the sightless hearer. Of course, it does not speak any hitherto known language but as its mechanical eye sweeps over the printed type, it utters musical sounds which vary with each letter, so after the blind hearer has learned this new musical language, he can readily understand what the optophone is saying.

Of course, the mechanical eye is a selenium cell which bridges a gap in a telephone circuit. As our readers doubtless know, the electrical resistance of selenium is varied by its exposure to light; the more intense the light, the less the resistance. The selenium cell, therefore, acts as a light-operated valve to control the flow of current through a circuit. If a pulsating light strikes the selenium bridge, a pulsating current will pass through the telephone receiver, producing a sound which may vary all the way from a ticking noise up to a high musical note, depending upon the frequency of the pulsations.

Some years ago it occurred to Dr. E. E. Fournier d'Albe that by means of the selenium cell, he could let light shine into the black world of the blind through their ears. Next to sight, hearing is the most delicate sense possessed by man. When deprived of eyesight all the other senses are acutely developed particularly the sense of hearing and Dr. d'Albe sought to make the ears of the blind take the place of their eyes. His first aim was to produce an instrument which would enable a blind man to distinguish objects around him, as we do with our eyes, by noting the various shades of light reflected by such objects. The outcome of his experiments was the optophone. In this instrument, he used a selenium cell to control the current passing through a telephone receiver. This current was interrupted by means of clock driven mechanism so as to produce a buzzing noise in the receiver. With it the blind operator could distinguish shades of light by the loudness of the buzzing sound.

This was a rather crude attempt at converting sight into hearing. Since then, however, Dr. d'Albe has perfected the optophone with the special purpose of enabling the blind to read ordinary type matter. The inventor's own description of his instrument may be found on page 109 of the present issue and it will be seen that the instrument is a decided success. It has been tested out in actual practice and a number of blind operators are now able to read any ordinary printed matter. The optophone has opened up to them the whole of the world's literature.

However the possibilities of the selenium cell have not yet been fully realized. Now that the blind are enabled to read by ear may not further experiments be performed along the lines of the first instrument so as to give audible vision to the sightless? It is quite conceivable that an optophone instead of being provided with a single celled eye may be furnished with a mosaic of selenium cells in much the same way as the retina is composed of light-sensitive rods and cones. In this way the world of color might be translated into a world of music and the blind would be enabled to see with their ears.

Setting the Tides to Work*

Discussion of Various Plans for Utilizing Tidal Power

THE idea of utilizing the rise and fall of the tides for power purposes has long been a favorite one. Up to the present, however, no power development of this kind, of any appreciable size, has been carried out. The comparatively recent arousing of interest in waterpower development in general, and the great advance in the cost of fuel, have been accompanied by a corresponding interest in tidal-power schemes, and their commercial possibility is at the moment the subject of serious investigation.

The power which may be developed from a tidal basin of given area depends on the square of the tidal range, and since the cost per horsepower of the necessary turbines and generating machinery increases rapidly as the working head is diminished, the cost per horsepower of a tidal-power installation, other things being equal, will be smallest where the tidal range is greatest. It is for this reason that the western, and especially the south-western, coast of Great Britain, and the western coast of France, are particularly well adapted for such developments, since the tidal range here is greater than in any other part of the world, with the possible exception of the Bay of Fundy, Hudson's Bay, and Port Gallelos, in Patagonia.

In Great Britain the highest tides are found in the estuary of the Severn, the mean range of the spring tides at Chepstow being 42 ft., and of the neap tides 21 ft. In France the maximum range occurs at St. Malo, where it amounts to 42.5 ft. at spring tides, and about 18 ft. at neap tides. The tidal range in the Dee is 26 ft. at springs, and 12 ft. at neaps, while the mean range of spring tides around the coast of Great Britain is 16.4 ft., and of neap tides 8.6 ft.

Many schemes of tidal-power development have been suggested from time to time. Briefly outlined, the more promising of these are as follows:

(*a*) A single tidal basin is used, divided from the sea by a dam or barrage, in which are placed the turbines. The basin

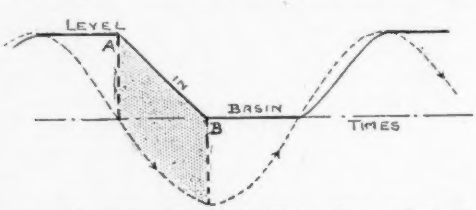


FIG. 1. WORKING PERIOD WITH SINGLE TIDAL BASIN, TURBINES OPERATING ON FALLING TIDE

is filled through sluices during the rising tide. At high tide the sluices are closed. When the tide has fallen through a height the magnitude of which depends on the working head to be adopted, the turbine-gates are opened, and the turbines operate on a more or less constant head until low tide. The maximum output from a given area of basin is obtained when the working head is approximately one-half the tidal range, and the cycle of operations under these conditions, and with a constant rate of fall in the tidal basin, is shown in Fig. 1. Here the dotted sine curve represents the level of the sea on a time base. The working period extends from A to B.

(*b*) A single tidal basin is used, with the turbines operating on both rising and falling tides. The cycle of operations is now indicated in Fig. 2. The working period per complete tide extends from A to B and from C to D. Slightly before low water, at B, the basin is emptied through sluice-gates, and at D, a little before high water, the basin is filled through the sluice-gates. With a working head equal to one-half the tidal range, the period of operation is approximately 50 per cent greater than in system (*a*), and the work done per complete tide is approximately 50 per cent greater.

(*c*) A single tidal basin is used with the turbines operating on both rising and falling tides. Instead of filling and emptying the tidal basin through sluice-gates at high and low water, and working under an approximately constant head, the water is allowed to flow through the turbines and to adjust its own level. Under these conditions the rise and fall inside the basin are cyclical, with the same period as the tide, but with a smaller rise and fall and with a certain time-lag. The range in the basin and the time-lag depend on the ratio of the sur-

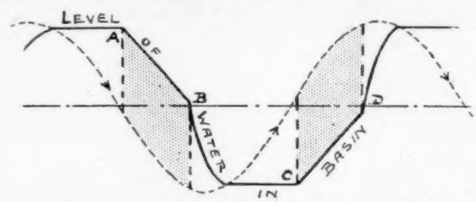


FIG. 2. CYCLE OF OPERATION OF SINGLE TIDAL BASIN, TURBINES OPERATING ON FALLING AND RISING TIDES

face area of the basin and of the effective discharge area of the turbines. The working head during each tide varies from zero to a maximum. The cycle of operations is shown in Fig. 3. The working period is from A to B and from C to D, where the head at the points A, B, C, and D is the minimum under which the turbines will operate. The total working period per tide is greater than with either of the preceding systems, and the possible output is somewhat greater. On the other hand, the variation of head during any one tide is very large.

(*d*) Two tidal basins of approximately equal areas are used, with turbines in the dividing wall. Each basin communicates with the sea through suitable sluice-gates. In one of these basins, called the upper, the water-level is never allowed to fall below one-third of the tidal range, while in the lower basin the level is not allowed to rise above one-third of the tidal range. The working head then varies from 0.53 H to 0.80 H, and operation is continuous, as indicated in Fig. 4, which shows the cycle of operations. The upper basin is filled from the sea through the appropriate sluice-gates from A to B, and the lower basin discharges into the sea from C to D. For a given total basin area and a given tidal range the output is only about one-half that obtained in system (*a*), and one-third that obtained in systems (*b*) and (*c*), so that, except where the physical configuration of the site is particularly favorable, the cost per horsepower is likely to prove very high.

(*e*) Two tidal basins of approximately equal size are used. Turbines are installed in the walls dividing the sea from each basin. Fig. 5 shows the cycle of operations. From A to B the upper basin discharges through its turbines into the sea. From B to E the sea enters the lower basin through its turbines. The upper basin is filled from the sea through its sluice-gates between C and D, and the lower basin is emptied through its sluice-gates from F to G. The head varies from 0.25 H to 0.62 H, and the output is some 25 per cent greater than in system (*d*), but the number of turbines required is much greater than in (*d*).

It is possible, at the expense of additional complication, to arrange in each of these systems that the head shall be maintained constant during any one working period, but since this means that the working head must then be the minimum obtaining during the period, a loss of energy is involved, with a great additional cost of construction and complication in manipulation, and with little compensating advantage.

*Reprinted from *Nature* (London), June 3, 1920.

The great difficulty in developing a tidal scheme as compared with an orthodox low head water-power scheme arises from the relatively great fluctuations in head. In any scheme in which the working head is a definite fraction of the tidal range, the working head at spring tides is much greater than at neap tides. In the case of the Severn, for example, the working head at spring would be twice as great as at neaps,

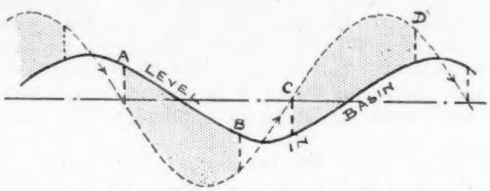


FIG. 3. SINGLE BASIN FILLING AND EMPTYING THROUGH TURBINES, WORKING HEAD VARYING FROM ZERO TO MAXIMUM

and the energy output per tide would be four times as great at springs as at neaps, while at St. Malo the output would be 5.5 times as great at springs as at neaps.

Not only is the installation subject to this cyclical fluctuation of head, but in any simple scheme the turbines also cease to operate for a more or less extended period on each tide; and as this idle period depends on the time of ebb or flood tide it gradually works around the clock, and will, at regular intervals, be included in the normal industrial working day. It is true that schemes of operation such as have been indicated are feasible in which this idle period may be eliminated and continuous operation ensured, but only at a considerable reduction of output per square mile of tidal basin area. Even in such schemes, unless the working head is fixed with reference to the tidal range at neap tides, the variation of head between springs and neaps causes the output to be very variable.

In any installation, then, designed for an ordinary industrial load, unless the output is cut down to that obtainable under the minimum head available at the worst period of a neap tide, in which case only a very small fraction of the total available energy is utilized and the cost of the necessary engineering works per horsepower will, except in exceptionally favorable circumstances, be prohibitive, some form of storage system forms an essential feature of the scheme.

Various storage systems have been suggested. Electrical accumulators must be ruled out, if only on account of the cost, and the same applies to all systems making use of compressed air. The only feasible system appears to consist of a storage reservoir above the level of the tidal basin. When-

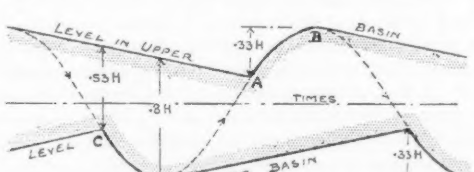


FIG. 4. TWO BASINS WITH TURBINES IN DIVIDING WALL

ever the output of the primary turbines exceeds the industrial demand, the excess energy is utilized to pump water into the reservoir, and when the demand exceeds the output from the primary turbines it is supplied by a series of generators driven by a battery of secondary turbines operated by the water from the storage reservoir.

Evidently this method is available only when the physical configuration of the district affords a suitable reservoir site within a reasonable distance of the tidal basin. Unfortunately also, considerable losses are inevitable in the process, and the energy available at the switchboard of this secondary station is only about 50 per cent of the energy of the water utilized by the primary turbines. Where two tidal schemes at some distance apart differ sufficiently in phase, it is possible, by working the two in conjunction, to reduce or eliminate the idle period between tides, and thus to reduce the necessary storage somewhat; but this does not affect the necessity of storage as between spring and neap tides.

Since storage reduces the available output by one-half, and at the same time complicates the system, besides adding considerably to the first cost and maintenance charges, the prospects of tidal-power schemes would be much more promising if the whole of the output could be utilized as it is generated. By feeding into a distributing main in conjunction with a large steam station or inland water-power scheme, and delivering to an industrial district capable of absorbing a comparatively large night load, such a state of affairs might be realized, at all events approximately. There is also the possibility that the intermittent operation of certain electrochemical processes may be developed so as to enable any surplus power to be absorbed as and when available.

Owing to the relatively large variations in working head in any simple scheme, and to the small working heads, the design of hydraulic turbines capable of giving constant speed with reasonable efficiencies, and of moderately high speeds of rotation, is a matter of considerable difficulty. Modern developments, however, promise much better results in both these respects than would have appeared possible only a few

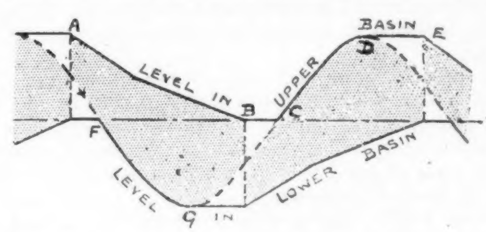


FIG. 5. TWO BASINS WITH TURBINES INSTALLED IN THE SEA WALLS

years ago, and turbines are in existence which are capable of operating under a variation of head equal to 50 per cent on each side of the mean, with efficiencies which do not fall below 70 per cent over this range, and with reasonably high speeds of rotation under the heads available.

Even with such turbines, the number of technical problems to be solved before a tidal scheme of any magnitude can be embarked upon with confidence is large. The questions of single- versus double-way operation, of storage, of the effect of sudden changes of water-level due to strong winds, of wave effects, of silting in the tidal basin and of scour on the downstream side of the sluices, of the best form of turbine and of generator, and of their regulation and of that of the sluice-gates, are probably the most important, though not the only, subjects to consider.

On the other hand, the possibilities of tidal power, if it can be developed commercially, are very great. Assuming a mean tidal range of only 20 ft. at springs, and 10 ft. at neaps, and adopting the single-basin method of development with operation on both rising and falling tides, each square mile of basin area would be capable, without storage, of giving an average daily output of approximately 110,000 horse-power-hours. In such an estuary as the Severn, where an area of 20 square miles could readily be utilized with a spring tidal range of 42 ft., the average daily output, without storage, would be approximately 10,000,000 horsepower-hours.

At the present time it is difficult to obtain an even rough estimate of the total cost of such a scheme, owing to the uncertainty regarding many of the factors involved. The whole question would appear to merit investigation, especially on matters of detail, by a technical committee with funds available for experimental work.

Green Rays at Sunset*

Explanation of the Curious Emerald Light That Sometimes Follows the Setting Sun

By Ch.-Ed. Guillaume

Correspondent of the French Institute

WHEN the sun has set and disappeared behind the horizon of the ocean, the last witness of its presence is at times a ray of light of a brilliant emerald green and of a very brief duration.

This is one of the most beautiful spectacles in nature to those observers who are fortunate enough to see it under such conditions as to occasion the exhibition in its full intensity. It is rare in the climate of France, but is frequently observed upon the waters of the eastern Mediterranean and is almost always observable in the Red Sea.

The cause of this green ray has remained rather obscure; its objective reality has even been disputed, according to which view any attempt at physical explanation is unnecessary, it being considered as due purely to physiological causes; finally, I may mention to show how extensively has been the search for its cause, that upon the discovery some twenty years ago of the presence of new gases in the atmosphere, it was suggested that the reason for this peculiar tint exhibited by the last ray of the sun might be found in the absorption caused by the passage through one of the said gases to be found in considerable quantities at the level of the sea.

This question having been put to me quite recently I took occasion to discuss it with M. H. Chrétien, the learned and well-known astronomer of Nice, and it was in the course of our conversation that the hypotheses were propounded which appear to make it possible to formulate a satisfactory theory of this mysterious phenomenon.

To begin with a number of observations have proved that the presence of the sea is not required for its appearance. M. Chrétien has seen the green ray produced when the sun disappeared behind the Esetrel, he himself being at the time stationed upon Mont Gros, in such a manner that this last ray was practically horizontal. This observation eliminates an entire series of hypotheses which otherwise might appear tempting.

The spectrum of the green ray does not seem to have been observed; this is to be regretted since a determination of its precise causes would be assisted by a knowledge of whether the spectrum exhibited lines, bands, or a continuous color.

Total reflections, due to a definite stratification of the layers of the atmosphere, while quite possible, would demand for their appearance such an improbable combination of circumstances that it is hardly possible to believe that such reflections can account for the frequent appearance of the green ray under the necessary conditions, the most essential of which is that the horizon be absolutely free from fog or mist.

Let us seek for an explanation, therefore, in superposition of the classic phenomena of dispersion and absorption. near the horizon the highly refrangible portion of the spectrum passes through only a very slight depth of the atmosphere and we may say consequently that for all practical purposes the solar radiations which reach the eye of an observer horizontally, are arrested shortly after the green. But it is a well-known fact that atmospheric refraction elevates the position of a star seen at the horizon, and the more refrangible the radiation concerned the greater the degree of the said elevation. Hence the green disappears later than the red and the only question which remains to be answered is the amount, whether appreciable or negligible, of the distance between the extinction of these two colors.

In the case of any radiation whatever, the path taken would be, for example, the line AB, curving downward as soon as the ray reaches the practical limit of the atmosphere; at the precise moment when the star disappears the last segment is horizontal, and the observer believes himself to perceive the star in the direction BC; at a tangent from the curve the amount of elevation is indicated by the angle ADC.

Under normal conditions this angle is 36′. At the equator where the stars pass through a distance of 15 degrees per hour the elevation retards their setting for 144 seconds of time. But the index of the refraction of the atmosphere is normally equal to 1.000292, and the dispersion of the average green to the average red is 0.000002. This last number is not strictly accurate, since it has reference to average positions chosen arbitrarily; but between each pair of qualified red or green radiations the distance remains of the magnitude indicated above. Keeping this for the sake of simplicity we find a ratio of the total refraction equal to 1/146, and we conclude, therefore, that there is a lapse of exactly one second of time between the disappearance of the red rays and that of the green rays. If this distance were much briefer the two impressions would be combined, while if it were much longer they would fail to benefit by the impression of contrast which assists so powerfully in the matter.

The last colors of the sun observed at the extreme horizon are plainly red; hence the eye which observes them becomes partially insensible to red, and, as a consequence, hyper-sensible to green. Since the sensation of green which is the last luminous sensation we see succeeds the sensation of red after the interval of a second, it is reinforced; thus we find that the brilliant green ray is the result of two causes, one of which is physical while the other is physiological in nature.

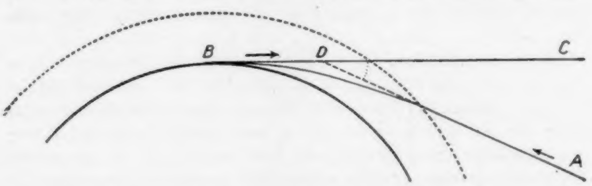


DIAGRAM ILLUSTRATING THE GREEN RAY PHENOMENON

It would seem that such a simple combination of causes ought to produce this rather rare phenomenon more often. However, a little thought reveals why it occurs rather seldom. As a matter of fact, absolute purity of the atmosphere at the horizon appears to be an indispensable condition on the one hand, while on the other when we consider the disappearance of the sun behind a mountain, under an angle such that fog and mist are generally absent, the interval of time which elapses between the passage of the red rays and that of the green rays is too short for the two sensations to be distinct. At ten degrees above the horizon, in fact, the degree of elevation is not more than five minutes of the arc, and the successive disappearance of the red and of the green occurs in a space of time hardly longer than one-tenth of a second. At this altitude, moreover, the sun still appears to be very white and the eye is not assisted as is the case at the horizon by the greater degree of sensitiveness to the green and by the absorption starting with the blue.

The physical conditions back of the appearance of the green ray are doubtless fulfilled more frequently in the morning than in the evening. But the physiological conditions, *i. e.*, the previous action of the red and the fixation of the eye upon the

*Translated for the *Scientific American* from *La Nature* (Paris).

point to be observed, are not so fulfilled, and consequently the sensation of the green rays can be obtained in the morning only by sustained attention preceded by systematic study. In the Arctic regions the phenomenon is capable of assuming a special aspect when the sun strikes the horizon at a very sharp angle. Even in a given latitude and on a given day the sun touches the horizon for a period of time amounting to several minutes. Thus, if the atmosphere is pure the physical causes may be dissociated from the physiological causes and the green ray may appear as a more durable phenomenon but with a manifestly diminished brilliance.

Possibly it has been observed, in any case, however, it is governed by rigid conditions of place, time, and atmospheric purity. In many cases one observes only what one knows ought to occur; the physical reality of a durable green ray being known to be a fact under the conditions just described, we are justified in believing that any close observer will have the privilege of confirming its existence.

The World's Supply of Energy*

The Problem That Faces Us When Our Supplies of Coal Are Exhausted

By Svante Arrhenius, Ph.D., M.D., D.Sc., LL.D.

SINCE the days of Watt the physical well-being of mankind has become more and more dependent on fossil fuels. The life of today would be impossible without the enormous supply of coal necessary to industrial establishments, for railways and steamships, in the metallurgical arts and for the heating and lighting of our houses. The demand for fossil coal has increased very rapidly, about doubling every ten years during the last century, and is now some 1,200 millions of metric tons per year. It is clear to those who have studied the matter that our coal fields will be exhausted after a certain time. When this calamity will happen, and the probability of the discovery of substitute sources of energy, are questions of vital importance.

One of these questions was answered by the Geological Congress in Canada in 1913. The quantity of fossil coal down to a depth of 1,800 meters would suffice for 6,000 years, at the present rate of consumption, if it were all recoverable, but a very great deal of this coal occurs in beds too thin for profitable working, a considerable part is lost as dust, or left in the mines as pillars, and, further, the use of coal will probably increase in the future just as it has done in the past. It is, therefore, necessary to reduce the indicated time considerably, probably to one-fourth, or about 1,500 years.

Of the different countries the United States, in the matter of coal, has the best position, as it has in the matter of other natural resources. The coal treasures there will probably suffice for about two thousand years. The worst situation among the great coal-producing countries is that of England, where the coals will be exhausted within a little less than two hundred years. Germany will be able to meet its demands during a little more than a thousand years.

This time of some few hundreds or thousands of years is very short compared with the time estimate made at the Geological Congress referred to, and only about one per cent of the period of man's existence, which probably lies between the thousandth and ten-thousandth part of the time during which life has existed on our earth. It is quite clear that we must soon ration our coal, and substitute as far as possible for fossil fuel other sources of energy.

It is often suggested that we might use mineral oils as fuel instead of coals. This advice rather reminds one of the words of Marie Antoinette: "If the people complain that they have no bread to eat, why do they not eat cakes?" Petroleum is a far more valuable fuel than coal, because it is much easier to transport and to use effectively. The world's yearly production of mineral oils represents not quite three per cent of the energy contained in the yearly production of coal. Petroleum ought, therefore, to be reserved for better purposes, *e.g.*, production of light and lubricants. Further, the recent failure of many oil fields indicates that we must economize this valuable material. According to David T. Day, U. S. Geological Survey, the production per well in the Appalachian oil field decreased from 207 barrels in 1861 to 1.73 barrels in 1907. The production of West Virginia had, in 1910, declined 56 per cent from its maximum output. The oil obtained from the New York and Pennsylvania oil fields fell to 50 per cent from the year 1891 to 1898. If we suppose the present fields of the United States and the present rate of exploitation should continue, petroleum would be exhausted by about 1935, and if the present production goes on with no increase, the product would be exhausted in about ninety years, said Charles R. van Hise in 1910, who has done so much to warn against waste in the expenditure of our natural resources. The output of mineral oil has been kept up through an enormous increase in the number of oil wells in each field, and by opening up new fields, *e. g.*, in Oklahoma and California. There are very rich new oil fields in the world which are still not used, or only in a small degree, *e.g.*, in Mexico and Mesopotamia and Turkestan, but certainly they will not last as long as the coal fields, even if the production of this fuel is restrained to but three per cent of the simultaneous production of the latter.

Still much less is the hope that sources of natural gas may deliver more than a small fraction of the fuel value of the oil fields. Even peat, although an important fuel, can by no means compete with coal. Thus, for instance, in the United States the available peat is less than one-half of one per cent of the estimated coal. Probably the relative value of the European peat bogs is about the same as compared with the European coal fields. For heating purposes petroleum and peat cannot play an important rôle as compared with fossil coal.

It is very often said that for coal should be substituted the water power of our rivers, often called "white coal." According to an estimate of Engler, the energy which might be economically taken out from these waterfalls amounts to about 60 per cent of the energy of the present output of coal. But even this figure seems too high, for many of the waterfalls are located in rather inaccessible parts of the world, where no industry is likely to be developed for a long time. So it seems wise to reduce the figure of Engler about 50 per cent. If this is done, it is evident that there is little hope that white coal will be able to substitute for black, except in a small degree. For heating purposes water power will probably not be used in a noteworthy degree, because used directly for the production of mechanical or electrical energy it is at least three times as valuable as the equivalent quantity of heat. Further, the well-situated waterfalls are already developed in greatest part, at least, in Europe. Thus, for instance, in Switzerland nearly all the waterfalls which have a commercial value are developed and in a little less degree the same is true in all the other industrial countries of Europe.

During the unhappy situation created by the world war, when there was a great scarcity of fuel, and even now, when fuel is extremely expensive, waterfalls were and rapidly are being put to use. Within a short time, therefore, this source of energy will be taken into the service of man, not sensibly

*Paper read before the Franklin Institute, Philadelphia, on May 19, 1920, at the presentation of the Franklin Medal to Dr. Arrhenius Reprinted by courtesy of the *Journal of the Franklin Institute*.

THE SHUMAN SOLAR POWER PLANT IN OPERATION NEAR CAIRO, EGYPT

diminishing the demand for coal. An estimate of the power of the waterfalls has been made by Koehn and by Keplan, and is of much interest. Although the figures are only approximate, I give them below, with some later corrections. The power is given in millions of horse-power and horse-power per inhabitant:

Country	Horse-power in Millions	Horse-power per Inhabitant
Asia	236	0.27
Africa	160	1.14
North America	160	1.17
South America	94	5.25
Europe	65	0.13
Australia	30	3.75
Total	745	Average 0.45

Country	Horse-power In Millions	Horse-power per Inhabitant
Canada	26	4
United States	100	1
Iceland	2	22
Norway	13	5.2
Sweden	6.7	1.2
Finland	2.6	0.8
Balkan Countries	10	0.6
Switzerland	1.5	0.4
Spain	5.2	0.26
Italy	5.5	0.15
France	6.0	0.15
Austria-Hungary	6.2	0.12
Germany	1.43	0.02
Great Britain	1.0	0.02
Russia	3.0	0.02

These figures are not altogether reliable. Thus, for instance, Leighton gives for the United States 200 millions, and van Hise says: "Others regard this estimate as too high, and say 100 million horse-power is nearer to truth." I think this latter figure is more to be depended on. Van Hise is of the opinion that even it will meet the needs of a population of 250,000,000. Since his estimate made in 1910 the demands for power have greatly increased, and probably only about one-half of the energy given in the table above is available at present without excessive initial expenditures. We may, therefore, assume 0.5 horse-power per inhabitant as adequate to present needs. We find then that Europe and Asia are the only parts of the world where water power is really scanty—in Asia the demand is still so small that even this power per inhabitant is more than sufficient. Especially fortunate are those countries, such as South American Republics and Australia, where water power per unit of population is well beyond this figure, and may be developed at a moderate cost. The United States is among the great powers very well endowed in this regard, as in most other natural sources of wealth, such as metal, ores and coal. In Europe, Iceland ranks first, because of its small population, and the old Saga Island may yet know a new and flourishing era. Then come the Scandinavian countries, the first being Norway, which has already greatly profited through its cheap power, and is destined to be one of the leading industrial countries of the future. Sweden and Finland possess enough power for their needs. Their waterfalls are not high, and in general are far from established lines of communication, especially from those of the ocean. Denmark has scarcely any water power, as also Holland. Among the other countries of Europe the Balkan States have more power than their industrial needs require. Switzerland may also be regarded as having a nearly sufficient supply of water power, which is the more fortunate, as this highly industrial country does not own any coal deposits. The same is true of the new Austria, which has lost its old coal districts but has retained by far the greater part of the waterfalls of the old Austria, so that it now probably ranks with Switzerland in this respect. Spain is also a relatively well situated state, but which up to the present has not made much use of its resources. In general, the waterfalls in the Alps, Spain, Italy and the Balkans are high and of great value. For the industries of France and Italy water power is of the greatest importance, although it must be regarded as insufficient for nations so highly developed. At the end of the list come the three great powers of Great Britain, Germany and Russia, with only a fiftieth horse-power per inhabitant. Russia is an agricultural country, with a very small demand for power, and agriculture will probably remain its chief industry because of its small power resources, both in coal and water. England and Germany, now the most highly developed industrial countries in the world, will undoubtedly also in the future have agriculture for their chief industry. Probably a great part of these countries will again be covered by forests, as they were in the time of Tacitus.

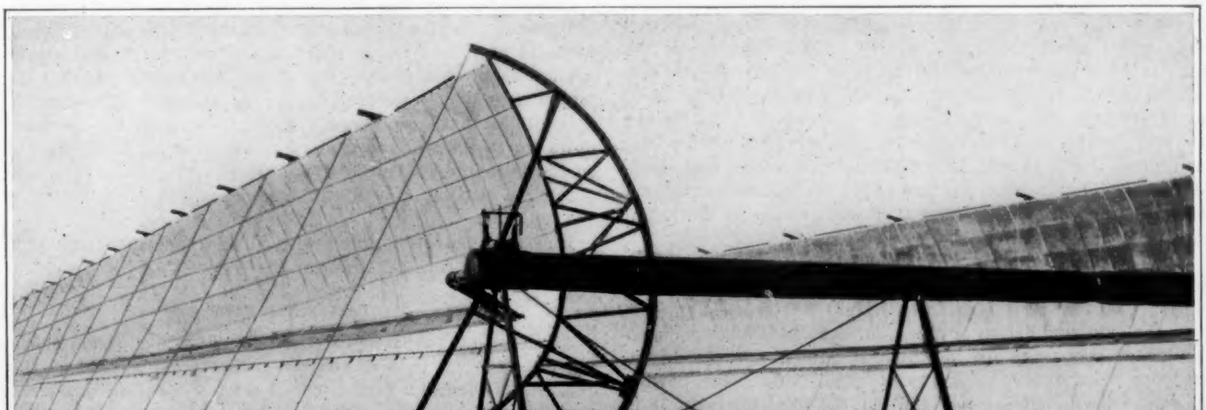
It is often asserted that the power of tidal waves should be utilized. Of course, this is possible, but doing so on a large scale would involve an initial investment not justified by prices likely ever to be obtained for power. The energy of the tidal wave is so widely distributed along the shores of the oceans that it is impossible commercially to collect a sensible part of it. It is quite in contrast to the energy of fossil fuel and waterfalls.

All available energy on the earth has its origin in solar radiation. Of this energy a small part, 0.12 per cent, is accumulated in vegetation, which, however, is great as compared with the energy of the coal burned in the industries. A detailed calculation, made by Professor Schroeder, of Kiel, shows that about twenty-two times as much energy is yearly accumulated in plants as is represented by the coal consumed in the same time. Of this energy in vegetation 67 per cent is taken up by the forests, 24 per cent in cultivated plants, 7 per cent in the grass of the steppes and 2 per cent on desert lands. The energy collected by forests may be used for heating purposes, and exceeds every year that of the coals burnt by about fourteen times. But, unhappily, the greater part of this energy is collected in tropical areas, and the highly cultivated countries are so nearly deforested that their production of wood is not nearly sufficient as fuel for their industries. Further, the wood produced in civilized countries is needed for the production of paper, pulp and lumber. In forest lands the refuse from the woods may be sufficient for domestic purposes, and during the war even the industrial needs of certain countries for combustibles were met by wood, where the importation of coal was hindered by the blockade. The costs, however, were very high, due to the expensive transport from the forests to the industrial centers. The transport of wood from the immnese forests in the tropics to industrial countries seems impossible on economic grounds. The forest lands possess, therefore, an advantageous position in this regard. Before other industrialized countries will be able to substitute wood for coal an economic solution of the transportation problem is necessary, which at present seems fraught with exceedingly great difficulties.

Two other sources of energy, greatly dispersed in form, remain to be considered, namely, those of the winds and of sunshine. They are extremely great, and exceed that of simultaneously burnt coal from 5,000 to 70,000 times, respectively. The energy of the winds is taken up by windmills, which have been in use in Europe since the eleventh century. The great objection to wind as a source of power is its variability, and the high installation costs per unit of power continuously deliverable. It has been proposed to store the energy of the wind by means of accumulators, charged from windmills, and to use these accumulators during times of calm. But even in windy countries, *e. g.*, Denmark, this method is extremely uneconomical, as compared with coal or wood at their present price. Windmills are widely used for pumping water, both in the new and the old world.

The radiation of the sun may be concentrated by means of mirrors on a boiler, and this connected to a steam engine. The best known of these solar engines was constructed by John Ericsson, and described in *Nature* in 1888. It was an improvement of an earlier machine constructed in 1860. In his experiments in New York, John Ericsson obtained an effect of one horse-power with a mirror of ten square meters' opening. Later, his experiments were taken up on a commercial scale by Mr. Shuman, of Philadelphia, who installed a solar engine, with mirror of 1,200 square meters in all, at Meads, 10 kilometers south of Cairo, in Egypt. The machine was of the Ericsson type, with some small modifications, and auxiliary apparatus. Shuman did not obtain more than half the effect of that obtained by Ericsson, namely, one horsepower per twenty square meters mirror opening. After an inspection of Mr. Shuman's plant, Mr. Ackerman thought it possible to introduce improvements which would give as good results as those obtained by Ericsson.

After improvements the solar engine seems likely to play an important rôle in the opening up for cultivation of great arid districts in tropical countries, as Ericsson maintained with great energy it would do. In these parts of the world are great deserts, such as Sahara, the Arabian desert, the Syrian desert, and those in Mesopotamia, which have in historical times been the seat of flourishing culture, but are now the home of wandering tribes. The decay of these regions resulted from the destruction of their aqueducts and irrigation plants, which the present wandering population is unable to restore. With the aid of the solar machine it would be possible to re-establish the old agriculture and horticulture of these districts, and industrial works founded on its use might also be looked forward to. It is not only in the deserts that the sun is shining nearly continuously during the greatest part of the year, but extensive provinces in Spain, Greece and



THE ROCKING MIRRORS WHICH TURN WITH THE SUN AND FOCUS THE RAYS ON THE BOILER TUBES AT THEIR AXES

North America possess such a climate that they would profit by the introduction of the solar engine. In other parts of the world, where the sky is covered for the greatest part of the year, as in the Congo or the Amazonas, or which lie nearer to the poles, as the temperate regions, the solar machine will be of very little use.

It seems very probable that when fossil fuel has been consumed, civilization and culture will return to its birthplace about the Mediterranean and in Mesopotamia in the old world, and to Central America and the land of the Incas in the new.

According to some calculations made by me an increase of the carbonic acid in the atmosphere will give the whole earth a more uniform and warmer climate. Therefore, we may suppose that the burning of coal will cause our climate to approach to that of the tertiary age. Furthermore, vegetation is highly stimulated through absorption of carbonic acid in the soil, augmented through an increase of the carbonic acid in the air. It is, therefore, probable, as I have tried to show in my book, "World's in the Making," that the total consumption of the available coal by the industries will, in a high degree, favor agriculture and the growing of forests in the temperate regions now the chief seat of culture. These regions will then know not only harmful, but some useful consequences as the result of the present waste of our fuel resources.

Sunlight Engineering*

Its Relation to Housing and Town Planning

By H. L. Seymour

FIRST, I wish to mention some well-known facts about the sun and then I hope to show you that they should be considered in determining the direction and width of streets, the height, orientation and density of buildings, and similar matters of more or less importance in planning. I believe I am correct in stating that it is only recently that the application of such facts has been a matter of careful study.

How much weight should be given to this question of sunlight must be a matter of judgment in each case; there may be factors or conditions that make it of small importance. But in some instances it is of great importance and in general to the town planner is given the problem of the scientific utilization of sunlight in his lay-out of streets and buildings.

For the purpose of this paper I propose to divide the light derived during the day into (*a*) daylight or skylight, and (*b*) sunlight; with the latter we are mostly here concerned. "Skylight comes from all directions of the heavens; sunlight from only one direction, constantly varying with the revolution of the sphere."[1]

The astronomer has been searching the heavens with telescopes of ever increasing size and power to bring to our knowledge far distant heavenly bodies. A similar search has been made by the bacteriologist with high-powered microscopes of also ever increasing magnification. These now disclose many small forms as cleverly hidden from us in the past as were the distant stars. Just as the astronomer feels certain that there are many bodies which he has not yet seen, so is it with the bacteriologist in his work. The latter, however, generally has various means of verifying his presumptions—for example, that of letting a bacterium indiscernible with the microscope, produce under favorable conditions a colony of such proportions that it is readily seen by the naked eye.

Some of these bacteria are beneficial to us, but others are not so friendly. Every contagious and infectious disease is caused as a rule by a specific bacterium or similar organism. Now the oxidizing action of direct sunlight and its accompanying drying properties are the greatest natural agencies in destroying disease or pathogenic bacteria. This point I wish to emphasize because I feel that in the final analysis, it is the strongest scientific argument that can be advanced, as far as housing is concerned, for direct sunlight. In a cubic metre of air taken from over the ocean there was found only one bacterium. In the same amount of air taken from a Paris hospital there were 79,000 bacteria. In the open air of the country there are many less than in the city air, which, as a rule, is shut off from direct sunlight.

"Second only to air is light and sunshine essential for growth and health, and it is one of nature's most powerful assistants in enabling the body to throw off these conditions which we call diseases. Not only daylight but sunlight; indeed fresh air must be sun-warmed, sun-penetrated air. The sunshine of a December day has been recently shown to kill the spores of the anthrax bacillus" (*Healthy Hospitals*, Sir Douglas Galton, Oxford, 1893). This latter is no mean performance when one remembers that bacterial spores or "seeds" are protected with a hard casing which renders them much more difficult to destroy than the parent bacteria. The figures given for the duration of life of the tubercle bacillus are as follows:

Dark places	2-18 months
Diffuse daylight	6-24 hours
Sunlight	10 min -1 hr.

Besides being nature's great preventative for the spread of disease we all have felt the exhilarating effect of sunlight and know its general effect on public health and sanitation.

"Unquestionably one of the first requisites for a healthy building is abundance of sunlight. Not only the exterior wall surfaces of the buildings but also the surface of the ground around them should have the direct rays of the sun for as long a time as possible each day," says Atkinson. The amount of sunlight that may actually enter into rooms by the windows set in the walls is also of great importance and mostly so in the winter when windows are closed and there is not possible a circulation of air that has been sun-purified outside the building.

I assume that you agree with these conclusions and will pass on to the considerations of the

ASTRONOMICAL DATA

Atkinson has prepared for Latitude 42°N. a diagram showing the apparent path of the sun for different months in the year. The condition of the winter solstice may be considered as fairly typical of the period of the four months from October 21st to February 21st. For the northern climes this is the period for which special planning is necessary as can be judged from the following reasons, with which you are all very familiar but which will bear some elaboration.

1. *At the winter solstice the days are the shortest*, which means that the total possible amount of sunlight that can be received per day is the least in the year. A nomogram has been prepared in the Surveyor General's office from which the duration of sunlight in Canadian latitudes can be quickly

*Abridgement of a paper presented at the Ottawa Center of the Royal Astronomical Society of Canada. Reprinted from the *Journal of the Royal Astr. Soc. of Canada*, May, 1920.

[1]Atkinson, "Orientation of Buildings," to which work I am indebted for much of the information in this paper.

determined.[3] The effect of latitude on the length of the day is readily apparent:

	Lat.	Duration of Sunlight
At the summer solstice......	42°	15.25 hours
	60°	18.90 "
At the winter solstice........	42°	9.10 "
	60°	5.85 "

2. *At the winter solstice the sun's rays are most oblique.* For example, at noon, December 21st, the altitude of the sun is only about 15° at London, England (Latitude 51½°N.), which is but little north of Calgary, Alberta.

As you know, the intensity of heat and light received from the sun is greatest as the rays become most nearly vertical. We find then that not only the total amount but also the intensity of the sunlight received in winter is less than that received in summer. That we should plan to conserve all the sunlight we receive in the northern climes in the winter is the obvious conclusion. If we do this we shall be amply rewarded.

3. *At the winter solstice the shadows cast are the longest and cover the greatest area.* In this connection some facts are of interest as to some of the New York Skyscrapers. These facts and others in this paper are taken from recent papers by Messrs. Swan and Tuttle on "Planning Sunlight Cities" and "Sunlight Engineering in City Planning and Housing":

"At noon, December 21, the Woolworth Tower, 791 feet high, casts a shadow of 1,635 feet in length.

"The Equitable Building at the same time, being 493 feet high, with a ground area of 1.14 acres, casts a shadow 1,018 feet long, covering an area of 7.79 acres, with the result that the fronts or facades of many tall buildings are completely shaded all day.

"The street on the north of the Equitable Building is 34 feet wide. If this east and west street were built up of Equitable Buildings then 'not a single window within 447 feet of the street level would receive a ray of direct sunlight on December 21.'"

At noon on December 21st the altitude of the sun is at the places named approximately as follows:

At the Equator	66.6°
At Winnipeg	16.6°
At Edmonton	13.0°

On east and west streets if the whole south front of buildings on the north side are to receive sunlight at noon December 21st, then the width of the street must be:

At Equator	0.43	times	the	height	of	buildings	on	south side
At Winnipeg	3.33	"	"	"	"	"	"	"
At Edmonton	4.33	"	"	"	"	"	"	"

Or the shadow cast at Winnipeg is in length 7.77 times that at the equator; at Edmonton 10 times that at the equator (at noon, winter solstice).

As the condition at the winter solstice is evidently the most unfavorable for sunlight planning and because, as shown, such condition obtains to a great extent from about the middle of October to late in February, this condition should be the one to receive the greatest study. If ample sunlight can be provided for this period of four months, our problems are, with few exceptions, solved.

ORIENTATION OF DETACHED BUILDINGS

How should a detached building be constructed and oriented so that not only the exterior wall surfaces but also the surface of the ground around them have the direct rays of the sun for as long a time as possible on December 21st?

Investigation shows that by orienting our building with sides, northeast, southwest, etc., every side receives sunlight, except in the far north; and that for a detached building this position is preferable. This has been recognized in Switzerland, where cottages have their diagonals square with the cardinal points.

[3]See "Nomogram Showing Duration of Sunlight," by W. H. Herbert in *Jour. Royal Astr. Soc.*, Canada, October, 1919.

The matter of orientation is considered an important one for hospitals. The Central Alberta Sanitarium near Keith, Alberta, is a good egample.

ORIENTATION OF BUILDINGS IN RURAL AND RESIDENTIAL DEVELOPMENTS

Having found the best orientation for an isolated detached building, the next matter is to determine the effect of the grouping of buildings. Until the shadows cast by adjoining buildings are such that all sunlight is cut off from some surface of the building under consideration, or until there results a ground area or areas of perpetual shadow there would appear to be no advantage in changing the orientation of buildings considered favorable for isolated conditions. It can be shown that buildings on a north-south street must be much farther apart than on a northwest-southeast or a northeast-southwest street. It would appear then that streets in an open rural or residential development and where no important factor dictates otherwise, should preferably be placed so that buildings thereon and with faces parallel thereto, have their sides at an angle of 45° with the cardinal points. This means that streets in such a development should run northeast-southwest and northwest-southeast and not north-south and east-west as is the general custom. Kipawa, Quebec, is an actual case in course of development, having been planned by Mr. Thomas Adams, Dominion Housing and Town Planning Adviser.

ORIENTATION OF ATTACHED BUILDINGS

Writing in 1864, Horace Bushnell in his essay on City Plans (*Work and Play*) said:

"It is also a great question; as respects the health of the city, in what direction, or according to what points of the compass, the streets are to be laid. To most persons it will appear to be a kind of law that the city should stand square with the cardinal points of the compass—north, south, east and west, and where this law appears not to have been regarded how many will deplore so great an oversight, and even have it as the standing regret of their criticism. Whereas, in the true economy of health and comfort, no single house or city should ever stand thus, squared by the four cardinal points, if it can be avoided. On the contrary, it should have its lines of frontage northeast, southwest, northwest and southeast where such disposition can be made without injury in some other respect; that so the sun may strike every side of exposure every day in the year, to dry it when wet by storms, to keep off the mold and moss that are likely to collect on it, and remove the dank sepulchural smell that so often makes the tenements of cities both uncomfortable and poisonous to health."

Mr. Bushnell has applied the considerations that affect single buildings and open development to the conditions of close or urban development. With this conclusion Atkinson also agrees. It will now be my endeavor to show whether or not Atkinson is justified in such conclusion.

Atkinson has prepared "shadow curves" for latitude 42°N. at the solstices and equinoxes for a height of attached buildings of one and one-half times the space between rows. This space is in many cities the width of the street, no set-back being insisted on. Mr. Atkinson states in his "Orientation of Buildings":

"In the north-south street the distribution is symmetrical, the buildings on either side receiving an equal amount. On the east-west street the north face of the street receives no sunlight during six months of the year, and the buildings on the south side are in perpetual shadow during the same period. In planning towns the east and west street should be avoided as far as possible, and where unavoidable, the buildings should be of moderate height and built in detached blocks. In the checkerboard plan the best distribution of sunlight is obtained when streets run northeast-southwest and northwest-southeast."

Mr. Atkinson might have added that his diagrams for lati-

tude 42°N. show that a street and the attached buildings fronting thereon will receive most sunlight at the winter solstice when the street is oriented north and south.

Messrs. Swan and Tuttle, previously referred to, have apparently approached the whole matter of sunlight illumination from a different angle—not emphasizing a study of detached buildings as Atkinson has done, but laying particular stress on the consideration of developments carried out on New York lines, where closely placed or contiguous high buildings face only on the main and not, to any extent at least, on the cross streets. They conclude that the main street will receive most sunlight when it is oriented north and south. This conclusion is supported by many useful tables prepared for latitudes from 25°N. to 60°N. though only at the winter solstice (the period most adverse for sunlight planning in northern latitudes). And it is shown that while no sunlight may be received all day on an east-west street as far south as Latitude 30 yet in Latitude 50 N., under the same conditions, a north-south street receives over an hour of sunlight.

"Blocks improved with houses in rows or with apartment houses, then, should have their length parallel to north-and-south streets and their breadth parallel to east-and-west streets."

Swan and Tuttle also recommend that:

"Blocks the length of which parallels east-and-west streets should be subdivided into lots fronting on minor north-and-south streets laid out across the narrow dimensions of the block before they are improved with attached houses."

Though long narrow blocks are common, it has been contended that in some cases such a development is neither economical nor desirable and blocks more nearly square are to be preferred.

Assume for a "square" block development, buildings to be attached in rows, to be in height one-half the width between these and similar buildings on opposite sides of the street, and to be located in Winnipeg, latitude 50°N. Then we find from Swan and Tuttle's tables that on December 21st, houses near the center of the sides of the block (or sufficiently far from street intersections to be uninfluenced thereby) will have their fronts exposed to direct sunlight as shown in Table I.

TABLE I

N-S—E-W Orientation				N-E—S-W Orientation			
Side	Total time on street facade	Time cut off by window	Net time entering room	Side	Total time on street facade	Time cut off by window	Net time entering room
North...	0		0	N.E...	0h 22m	all	0
East....	1h 52m	0h 50m	1h 1m	S.E....	2 39	1h 1m	1h 38m
South....	0		0	S.W...	2 39	1 1	1 38
West....	1 52	0 50	1 1	N.W...	0 22	all	0
Total	3h 44m		2h 2m	Total	6h 2m		3h 16m

The amount of sunlight that may shine on the rear of houses will vary with the size of the open space in the interior of the block as well as on account of the orientation of the blocks. But with the N.-S., E.-W., orientation there is a southerly row of houses which receives no sunlight on either the front or rear elevations nor in any rooms. With the other arrangement every house is sure of having at least one of its facades sunlighted, and sunlight can enter the rooms, if not from the front then from the rear.

With the northeast, southwest, orientation all the streets circumscribing the block receive some sunlight, while in the first arrangement there are two unlighted streets. If then the square block developed with attached houses is for sufficient reason considered desirable it should evidently be oriented with streets at an angle of 45° with the cardinal points for the conditions stated, though as the height of buildings and latitude increase the advantages disappear.

The foregoing may be considered more of academic than of practical interest, but it at least draws attention to the conclusions arrived at by all authorities, that if east-and-west streets are to be built upon buildings should be detached.

Consideration of the arrangement of windows and the disposition of rooms are important but reference must be made to the authorities already named.

We find then differences of opinion. If we agree with Atkinson, that for isolated buildings and for rural or open residential development the northeast-southwest orientation is generally to be preferred, we do not have to follow him when he concludes, with but little investigation, that city streets with intensive development should be oriented in a similar manner. We must also remember that Atkinson has considered only a latitude of 42°N. though giving us diagrams for the equinoxes and solstices. If we agree with Swan and Tuttle from a consideration of their numerous and comprehensive tables that city development should generally take the form of long narrow blocks with the main streets north and south we do not have to apply that conclusion to the single detached house or rural development in ordinary latitudes.

GENERAL CONCLUSIONS

A. *Detached Buildings.*

1. Isolated detached buildings should be constructed with their walls not square with the cardinal points of the compass but at an agle therewith—preferably 45°.

2. Detached buildings as usually grouped in rural and residential districts should be oriented as in (1), the streets on which they face running northeast-southwest and southeast-northwest.

B. *Attached Buildings.*

1. Long narrow blocks with high buildings should have their lengths on streets running north and south, and these conditions are suited to intensive city development.

2. Square blocks, with low attached buildings, should usually be oriented so that streets make an angle of 45° with the cardinal points.

3. Houses fronting on east-and-west streets should, if possible, be detached.

C. *Disposition of Rooms and Windows.*

1. As a rule attached houses, when fronting on east-and-west streets require a greater frontage than houses on a north-and-south street.

2. In general the disposition of rooms and windows should be planned in relation to the orientation of the building.

D. *Height of Buildings and Width of Streets.*

1. There is an intimate relation between the height of building and the width of street; and this relation must receive consideration particularly in high latitudes.

2. To illustrate the above conclusion and because of its general interest I submit a paragraph from "Rural Planning and Development" by Thomas Adams:

"Heights of building should have some relation to the width between buildings, in rural areas a low standard of height can be fixed with advantage to owners of land. This is needed not only to secure light and air, but to prevent traffic congestion in the suburbs in towns and on rural territory surrounding them. We should determine the question of light and air to buildings by fixing a minimum distance between all buildings on opposite sides of streets without regard to the width of the street itself, by limiting the amount of land in the subdivision which should be occupied by actual building and by requiring a minimum angle of light to all windows. Apart from special cases, where the evil of high buildings has already been established, no buildings should be higher than the width of the streets facing them, and rural municipalities at least have power to adopt this standard. Ample justification can be given from every point of view, including that of the interests of real estate, for such a limitation.

"For desirable results the street plan and building plan should not be considered separately but 'must be conceived and perfected in harmony.'"

The Type-Reading Optophone

An Instrument Which Enables the Blind to Read Ordinary Print

The Scientific American Supplement *of August 3, 1912, contained a description of an instrument for converting light into sound, which was designed to enable the blind to see by ear. This instrument, known as the optophone, was the invention of Dr. E. E. Fournier d'Albe of Birmingham University. Dr. d'Albe later developed a type-reading instrument by which the blind could read large print. Recently the instrument has been greatly improved in coöperation with Messrs. Barr and Stroud of Glasgow, the well-known instrument makers. It can now be adjusted for any ordinary type.*

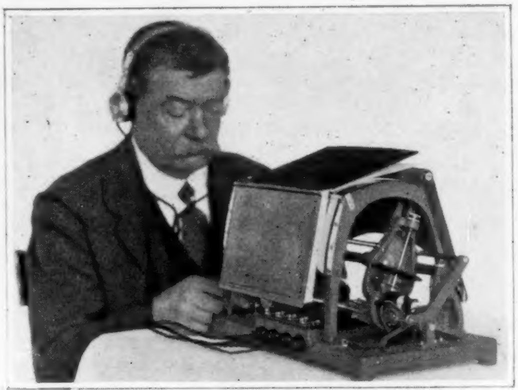


FIG. 1. A BLIND MAN READING BY EAR

The following description of the instrument is taken from an article by Dr. d'Albe appearing in Nature (London). We are indebted to the author and to Nature for the photographs reproduced herewith. The drawing on the opposite page is taken from The Electrician (London), which contains a very complete description of the optophone in the issue of August 13, 1920.—Editor.

The general principle of the apparatus is shown by Fig. 2. A siren disk, D, is run at about 30 revolutions a second by means of the small magneto-electric motor shown. It contains five circles of square perforations, the innermost circle having twenty-four perforations, the outermost forty-two, the other circles being intermediate and corresponding to the relative frequencies of certain notes of the diatonic scale. A line of light in a radial direction is provided by the festoon lamp L, and the image of the filament of this lamp is thrown upon the print by a system of three lenses on the other side of the selenium tablet S. The axis of the concavo-convex lens C is slightly tilted out of the axis of the other lenses for a purpose which is specified below. The general result of the optical system is to give a line of luminous dots on the print, each dot having a different musical frequency. The light constituting these dots is diffusely reflected back on to the selenium, which is put in circuit with a battery and a high-resistance telephone receiver. Those dots which fall on white paper produce a note of their own musical frequency in the telephone, while those which fall on black are extinguished. We thus get what may be called a "white-sounding" optophone, in which the black letters are read by the notes omitted from the scale rather than by the notes which remain sounding. All the reading demonstrations hitherto undertaken have been given with a "white-sounding" optophone.

A modification of this principle, introduced by Messrs. Barr and Stroud in consultation with the writer, is the provision of a second selenium preparation in the form of a cylindrical rod, the top of which can be seen at B (Fig. 2). This rod receives the light reflected by the concave surface of the lens C, which produces a real image of the line of dots on a generator of the cylindrical rod, and by turning this rod about its axis the image can be made more or less effective as desired. By balancing the effect on B against the effect on S, when white paper alone is exposed, a silence can be produced in the telephone, and the effect of the passage of a black letter is to make a sound which varies in accordance with the formation of the letter. This is the principle of what may be called a "black-sounding" optophone, and although its advantage over the white-sounding type has yet to be proved, there is little doubt that the learning of the alphabet sounded on the new principle will be easier, though in the writer's opinion the ultimate speed acquired by either black-sounding or white-sounding will be approximately the same. It is interesting in this connection to note that Miss Mary Jameson, the blind girl who gave the demonstrations at the 1918 Exhibition, now reads habitually at a speed of about

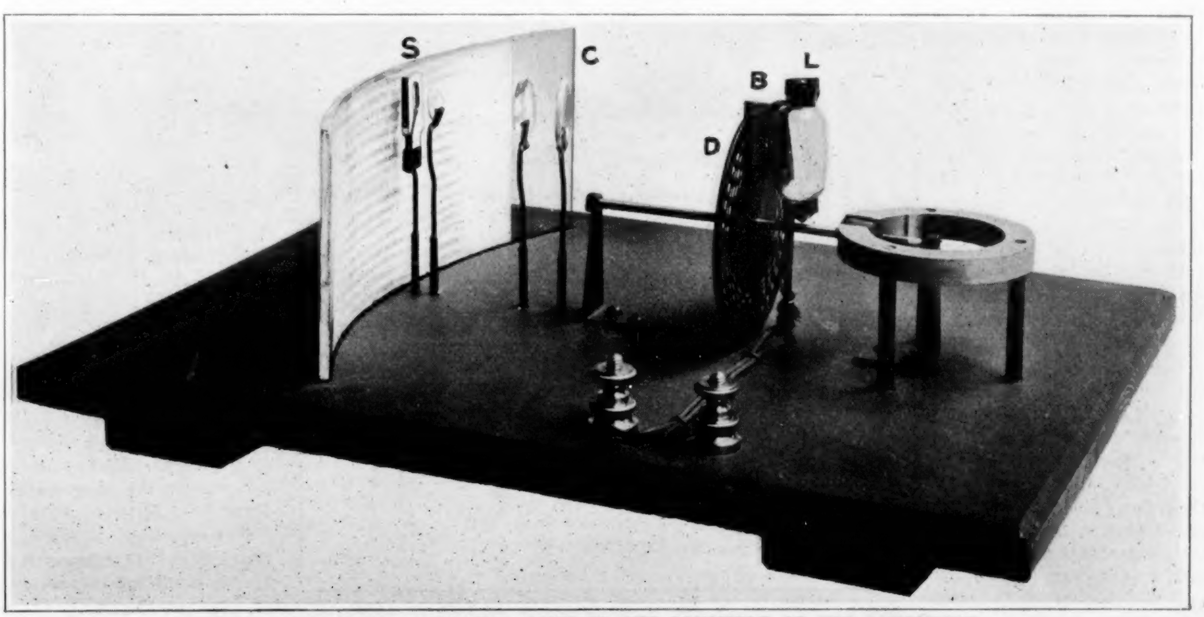


FIG. 2. SKELETON APPARATUS SHOWING THE PRINCIPLE OF THE OPTOPHONE

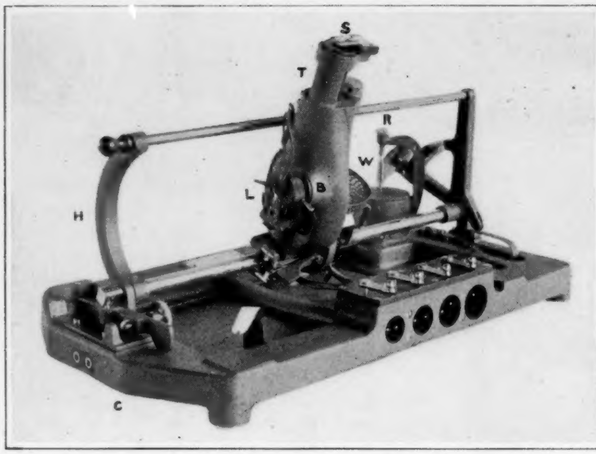


FIG. 3. THE OPTOPHONE WITH BOOK REST REMOVED

FIG. 4. THE OPTOPHONE COMPLETE WITH BOOK REST

twenty-five words a minute with a "white-sounding" optophone made by Messrs. Barr and Stroud, and finds, indeed, that when the instrument is adjusted for a lesser speed reading becomes more difficult.

The present construction adopted by Messrs. Barr and Stroud is shown in Fig. 3. The disk, lamp, lenses, and selenium, as well as the motor, are all mounted in the swinging "tracer," which can be brought over to the right by means of the reading-handle H. It then returns to the left with a slow, silent, and steady motion regulated by the worm gearing W, which drives a small paddle inserted in a viscous liquid. This paddle can be inserted more or less deeply into the liquid by the regulating nut R, and such is the range of adjustment possible that a line can be read in anything from five seconds to five minutes, according to the proficiency of the reader. When the line is read, the next line is brought into focus by the change-bar C, which works a friction grip inside the bar on which the "tracer" is pivoted, and can be adjusted for any desired line space by means of the screw attached to the change-bar. A lever attached to the "tracer" enables the operator to reverse this motion or to release the whole "tracer" from the friction gear, so that it may be quickly brought to the top of the page.

The festoon lamp is inserted at L, where it is held by a spring clip, and whence it can easily be removed for renewal even by a blind operator. The balancer is inserted at B, and can be adjusted for silence by means of the small handle shown.

Fig. 4 shows the apparatus from the top page end and with telephone and flex connections attached, as well as the book-rest V holding a book. The adapters of these flex connections are all of different sizes, and fit into different-sized holes in such a manner that they cannot be wrongly inserted—which is an important consideration with blind operators.

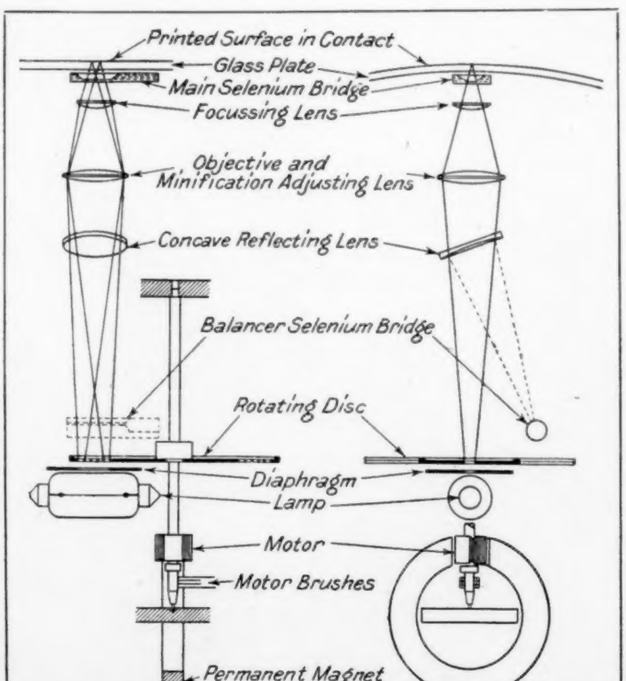


FIG. 5. DIAGRAM OF THE ARRANGEMENT OF THE OPTOPHONE

The various connections with their switches are for the motor, the lamp, and the two selenium circuits respectively. When the adapters are removed, a cover can be placed over the whole instrument, which clips on to the aluminum base, and the optophone can thereupon be carried about like a typewriter.

Special mention ought to be made of a contrivance for adjusting for various sizes of type. The middle lens of the three shown in Fig. 2 is mounted in a nut which can be screwed up and down within the "tracer" by means of two gaps cut in the upper cylindrical portion at T (Fig. 3). The nut is provided with six nicks across the rim, which enable a blind operator to count the number of turns of the nut, and thus to adjust for any definite size of type. This ingenious contrivance is, I believe, due to Dr. Stroud.

In practice it is found that, with the new apparatus, the various adjustments for size of type, length of line, and line interval are quite easily made by blind persons, and that the instrument, with all its delicate adjustments, can remain in use for a long time without anything getting out of order. It is therefore safe to say that the problem of opening the world's literature to the blind is now definitely solved.

[*We learn from The Electrician that the numbers of perforations in the siren disk are in proportion to the notes G, C,' D,' E,' G' (sol, do, re, me, sol) of the musical scale. The spot of light corresponding to low G falls on the lowest points of such letters as j, p, y, etc., the high G falling on the tops of capitals and high letters. The three intermediate spots cover the body of the lower case letters. With a "black-sounding" optophone the letter V is represented by the motif sol, me, re, do, re, me, sol.*—Editor.]

Stammering Scientifically Considered

What Are the Origins and Causes of Interference with Automatic Speech?

By Ernest Tomkins, M.E.

HERE is a theory of stammering to be examined: Stammering is conscious interference with automatic speech, prompted by a mistaken idea of disability, and originally induced by a temporary speech-interruption.[1]

A scientific attitude at once prompts the question, "Does the theory embrace the phenomena of stammering?" Affirmative answers for many of the phenomena have been given at various recent times in the scientific, medical and educational press:[2] so repetition of those answers would be superfluous. The answers to be considered are to questions more original and possibly more interesting.

THE EFFECT OF AN IMAGINED AUDITOR

It has long been recognized that a stammerer's impediment appears or disappears according as he has an auditor or not, but that an imagined auditor has the same effect has been brought to attention comparatively recently. Dr. Scripture, in his "Stuttering and Lisping," gives an interesting account of the reactions of a stammerer at the telephone. A switch in the line is manipulated by the doctor in the view of the stammerer so that the latter is led to believe that he is connected with an auditor or not, and his stammering occurs or vanishes according to that belief and not according to the actual connection. This phenomenon of the effect on the disorder of imagined presence or absence of an auditor is of frequent occurrence and the circumstances are of great variety. A stammerer who had resolved to rid himself of his impediment by copious reading aloud used to shut himself in his room and read Dickens by the hour. His brothers and sisters, partly in a spirit of fun and partly to hear the story, would quietly open the door a trifle and listen to the reading. One day the listeners made a noise which revealed their presence, whereupon the impediment immediately reappeared and the reading ceased. Thereafter when the reader imagined that the listeners were at the keyhole, he would be unable to continue until he had opened the door and assured himself that no one was there. A stammerer was riding on the railway with a congenial companion, and believing that the noise shut out all other listeners was discoursing volubly and with considerable fluency until he caught the eye of another traveler who appeared to be watching his lips. Imagining that this stranger was watching his lips for occasional spasm, the stammerer experienced so much difficulty that he had to remain practically silent for the rest of the ride. Subsequent indications were that the stranger had not noticed the impediment; but the mere imagination of an observer was sufficient to change near-fluency into near-muteness.

Will the speech interference theory embrace this phenomenon of stammering? Yes. When the stammerer believes that his impediment is heard or observed by an unsympathetic person—more accurately, by a person whose reaction will be embarrassing to the stammerer—he makes a conscious effort to avoid the impediment, and by this conscious effort he blocks his normal speech and makes the impediment.

THE IMAGINARY-REAL DIFFICULTY

Stammering is undoubtedly the most anomalous affliction known: A stammerer's speech is impeded in private conversation and fluent in public discourse; a stammerer's remark is completely blocked by a word which he struggles to say, but when an auditor asks what word troubles him the stammerer says it fluently;[3] will voluntarily repeat with ease a word which he has just uttered, but when *requested* to repeat he becomes dumb; and so on, through a long list of anomalies. But probably the chief anomaly is that the difficulty is both real and imaginary. Before this anomaly is covered it is worth while to mention what a stumbling block it is to all other theories than the speech-interference theory. Those that advance a tangible defect are of course negatived by the imaginary element; and those that advance pure imagination do not account for the struggle. Rudolf Denhardt's dilemma in the face of this anomaly is one of the most interesting in the literature of the subject. He demonstrated the imaginary nature of the difficulty and that demonstration is an admirable piece of work. But when he tried to account for the struggle, he denied this admirable demonstration by alleging the disorder to be a psychosis.[4] Most investigators since Denhardt have not recognized the imaginary element but pronounce the disorder to be a psychosis pure and simple—not exactly simple, for they make it mysterious—and in abandoning the imaginary element they show themselves to be less advanced than Denhardt was.

Will the speech-interference theory embrace this anomaly of combined realism and imagination? Yes. According to the theory the disorder is dual in its nature, involving both mental and muscular elements. The mental element is the mistaken idea of speech disability, and the muscular element is the effort exerted to overcome the imaginary difficulty. The effort constitutes a real obstacle to speech. So the obstacle, the impediment, the stoppage—whatever one desires to call it—is real; *but there is no defect whatever in the stammerer's constitution.* If the superficial investigators would only grasp these facts of the reality of the stoppage and the unreality of a defect they would save themselves from grave mistakes; but they blindly follow the old fallacious reasoning. The one who practices suggestion says, "I tell the stammerer that he has no difficulty and he becomes fluent, therefore I have told him the truth"; and the realist says, "Since the peripheral organs function abnormally the central organs must function abnormally, therefore there must be a mental defect," and neither one realizes that the conclusion of the other makes it necessary to guess again, but each tries to maintain his untenable position in characteristic demonstration of the unscientific procedure which has made the field the chaos which it is universally acknowledged to be.

[1]The speech-interference theory, probably originally (although not completely) formulated by Dr. Albert Liebmann, has been published many times since 1914; but this is believed to be the first presentation of a formula involving the origin. Former statements of the theory were met with the question, "But how did the interference begin?" and an explanation was necessary. The formula here presented not only anticipates this question but also gives the common casual factor, supposedly unknown as late as 1916. See "Some Recent Theories of the Causation and Treatment of Stammering," by Dr. G. Hudson Makuen, Medical Council, Sept., 1916, in which he says, "The problem of finding a casual factor which is common to all stammerers, therefore remains unsolved."

[2]"In Stammering and Its Extirpation," Pedagogical Seminary, June 1916, the sufficiency of the speech interference theory is shown for origin by sickness and by stuttering, for absence of the difficulty in solitude, absence in singing, absence on final consonants, absence in concert speaking or reading, increase of the difficulty by fatigue, apparent immunity of the women, and other commonly recognized phenomena.

[3]"Ein Patient stockte vor dem Worte kann" in dem Satze: "Kann nicht Fürstendiener sein," ohne einen Versuch zu machen, das Wort auszusprechen. Er griff mit der Hand in den Halskragen, schob ihn zurecht, als ob er ihn behindere und die freie Atmung gefährde, drehte den Kopf wiederholt zur Seite, brachte aber keinen Laut hervor. 'Welches Wort fällt Ihnen schwer?' fragte ich. 'Kann, kann ich nicht sagen,' erwiderte er unverzagt, nicht denkend, dass er das Wort eben zweimal stotterfrei ausgesprochen." Rudolf Denhardt, "Das Stottern Eine Psychose," p. 54.

[4]"Psychosis: in pathology, any mental disorder; any form of insanity." Century Dictionary.

Right here it is necessary to meet the contention that a "mistaken idea" or, as it is sometimes inadequately expressed, a "fixed idea" constitutes a psychosis. The proponents of the neurosis views and of the psychosis views are quick to jump at the conclusion that the acknowledgment of a mistaken idea is an admission of the defect which they allege. A fixed, illogical idea does constitute a neurosis in the broad sense, including both neuroses and psychoses; but either a mistaken idea or a fixed idea may be perfectly logical, and a logical attitude is not an evidence of insanity but of sanity. The stammerer's mistaken idea of disability and his fear of it are eminently logical, so his very affliction, crudely judged to be an indication of insanity, is in fact an evidence of sanity. The blocking of his speech is a reality, and his recognition of that blocking as a real impediment makes the stammerer saner than those who try to convince him that he has no impediment. Fear is the anticipation of pain (G. Stanley Hall); and the stammerer, having suffered the pain of ridicule and unkind attention, anticipates repetition of it, and is perfectly logical in doing so, for the past is our only guide to the future. Whoever tries to make out of the stammerer's mistaken idea, or his fear, an evidence of deficient mentality is merely advertising the deficiency of his own mental processes.

THE HABIT-DISEASE ANOMALY

It is characteristic of the writings of the disease proponents in the field of stammering that they inadvertently pronounce the affliction to be a habit. Practically all of the conventional discussions are of the disease persuasion, yet the careful reader will find stammering called a habit, often in the very demonstrations that it is a disease.

Will the speech-interference theory embrace these lapses from the disease view to the habit view? Yes. Most of the manifestations of stammering are clearly indicative of habit: origin by initiation, absence of lesions, intermittence of the stammering and the fluency, absence of complications, tenacity proportional to the extent of indulgence, lack of definiteness in recovery, and many other manifestations carry even unwilling conviction of habit; so even those who endeavor to make it a disease inadvertently call it a habit. But ordinary habits may be overcome by "trying." Yet the more the stammerer tries to overcome his difficulty the more it bothers him. That seems to indicate disease. Also, diseases are generally considered not to be subject to voluntary control; according to which stammering certainly appears to be a disease, for the stammerer's emotion often exceeds the bounds of ordinary belief, and the will alone is almost powerless against it. See how adequately the speech-interference theory embraces this habit-disease anomaly. Consider first the emotion. This is the remembrance of past humiliations. Whenever the stammerer has "tried" to speak, his efforts have been more or less mutilated, and his auditor has stared or smiled or shrugged his shoulders or made a cutting remark or turned away or interrupted with a remark of his own; and in anticipation of repetition of this humiliation the stammerer's fear becomes so intense that many of his physical processes are disturbed.[5]

There is little use in telling the stammerer that he has nothing to fear, for that contradicts his experience. A panorama of cruel humiliations comes up before him and he is unable to submerge those memories except by a distraction or, in some cases, by the influence of expert suggestion. It should be evident from this that the stammerer's emotion involves nothing of disease; it is the normal result of his experiences, the consequences of habitual fright.

Consider now the impediment. Although it is true that when the stammerer tries to talk he impedes his speech, it is also true that when he desists from "trying" to talk his speech comes fluently. So the impediment is really under voluntary control consisting in desistance from the effort rather than persistence in it. This fact of the controllability of the convulsive effort is one that is very frequently denied by investigators of stammering, and that denial necessarily leads to erroneous conclusions. Since the impediment is under voluntary control, it cannot be a disease in the accepted view of diseases. Moreover, since neither the mental element of stammering nor the muscular element contain anything of disease, the disorder itself can contain nothing of disease.

[5]See Fletcher's fine "Experimental Study of Stuttering," *American Journal of Abnormal Psychology*, April, 1914, Vol. XXV, No. 2, p. 203, in which he shows the reactions of the heart and other organs.

THE CURES OF A NON-CURABLE DISORDER

One may collect pages of claims of cures of stammering and may also collect pages of denials of these cures. Will the spech-interference theory embrace this anomaly? Yes, of course. It has never failed.

Remember the two elements of the disorder, namely the fear of disability, and the misdirected effort prompted by the fear. Frequently the fear is manifested by physical disturbances other than vocal or articulatory disturbances. That is to say, a stammerer may remain perfectly mute, not moving his facial muscles at all, yet his blushes, his shifting glances, his desire to escape, all indicate his emotion. But a stammerer can school himself to hide all evidence of his emotion. Then, by refraining from indulgence in efforts to talk—that is, by refraining from talking when the fear possesses him—he may pass as a normal talker, and the casual observer would be ready to swear on a stack of Bibles that he was cured. "Perfectly cured; 'never heard him stammer again,'" is one of the most stereotyped testimonies in such cases. Now it is a fact that a considerable proportion of stammerers conform to the case just described. Many factors contributed to bring them to that condition. The futility of the efforts to talk indicates the advisability of abandonment of the efforts, and once they are abandoned, peace of mind begins to come. Many stammerers are so situated that they cannot abandon the efforts for they are forced to talk, against all that is just and right, as in the case of the stammerers in the schools, where the oral exactions are continued by the educators at the behest of those who profit from the disability which is confirmed by those exactions. Desistance from the effort is also induced by what little is good in the current treatments. All treatments require desistance from the convulsive efforts and encourage calmness. The fortunate attendant on these treatments abandons the numerous injurious exercises but retains the practice of cultivating calmness and of desisting from the efforts. When he does that, he appears to be cured, although really the emotion is only slightly abated, and, in confirmed cases, years of the regimen will be necessary to abate the emotion to such an extent that he can really be considered to have recovered, that is, until his confidence has effectually submerged his painful speech-memories. From what has just been said it is evident that there are two classes of cases which afford basis for the alleged cures: the first includes those that refrain from the convulsive effort but are still potential stammerers, and this class numbers probably 95 per cent of the alleged cures; and in the second class are those who after years of desistance from the impeding effort have dissipated all troublesome fear of difficulty. The first class is certainly not cured; and as to the second class it is stretching the word "cure" to apply it to a recovery which necessitates a considerable proportion of a lifetime.

THE INCONGRUITY OF THE ORIGINS

Fletcher observes, "Just how being bitten by a dog can produce stuttering in the same fashion in which habits are acquired is not easy to see."[6]

And many other than Fletcher have been mystified by the incongruity of the origins of stammering. Even the learned courts of law are called to decide such questions. A Kansas court has decided that knees scratched as the result of drag-

[6]Fletcher, "An Experimental Study of Stuttering," *American Journal of Psychology*, April, 1914, p. 245.

ging by a machinery accident may cause stammering.[7]

A child swallows a thimble and stammering results, another has a bad dream and stammering results, still another falls off the porch and stammering results. No "deficiency" theory has ever embraced these incongruent causes—indeed, the sponsors of those theories generally beg the question or content themselves with endeavoring to embrace a few causes and ignoring the others. The speech-interference theory embraces all the verified origins. Understanding of the matter is facilitated by consideration of the cases acquired by imitation. What is the origin in those cases? *Temporary interruption to speech.* The merry imitator, oblivious to the suffering he is causing others and is about to experience himself, deliberately blocks his speech. He holds his mouth shut and attempts to talk, he holds his breath and attempts to talk, he exhausts his breath and attempts to talk, he sticks his tongue between his teeth, blocking the opening, and attempts to talk. *He interferes with his speech.* Notice, all you scientists—Dr. Liebmann always excepted—the little boy has analyzed stammering better than you have, and has recognized it as interference with speech. But the little imitator is not yet a stammerer. What is commonly called the "pathological stage"—although there is no pathology about it—has not yet been reacted. That occurs when the imitator, fearing that he will "catch" the disorder, makes a conscious speech effort to avoid catching it. By that effort he "catches" it; for the obstruction or impediment is always a conscious effort—an interference with normal speech.

The origin by imitation is a perfect example of all other origins with the one exception that this is the only origin which necessarily continues. The induction of stammering by mutism or aphasia has been a subject of considerable attention since the World War, and many commentators make the old mistake of assuming the inducing cause to continue. In the old discussions of the subject one frequently reads of cases of stammering arising from debilitating illness, and the history of the case is followed by the allegation that the illness left a deficiency of some kind, which deficiency remains as the continuing cause of stammering. In the case of stammering induced by aphasia—the circumstances of which are simply that the speech disability due to the aphasia induces a conscious speech effort, which, impeding speech, creates embarrassment, and thereafter the efforts are continued in order to avoid the difficulty—it is not unlikely that the aphasia may continue for an indeterminate time; but the continuance of the stammering is not dependent on the continuance of the aphasia, for stammering is its own continuer when it is indulged in, and generally the aphasia disappears but the stammering remains. If our investigators would firmly grasp the fact that only a temporary speech interruption is necessary to induce stammering they would be saved the unfortunate consequences of dragging the inducing cause along through the whole course of the disorder.

In the case of the skinned knees the learned court erred somewhat in its opinion although the decision seems to be sound. But the mistake it made is so general that no criticism of the court will lie: stammering is not nervousness. If all the investigators would grasp this fact the literature on the subject would be curtailed about one-third and there would be more chance of the truth's becoming known and of the relief of the stammerers to follow. But it is safe to say that the same old nervousness theory will live long—it is such an easy resort. What really happened in the case of the skinned knees is this: that the accident induced the boy to interfere with his speech. His normal speech might have been paralyzed by the fright, in which case he would begin the conscious efforts; or he might have been rendered unconscious, and before his normal speech had fully recovered he might have begun the conscious efforts; but in any case a temporary interruption would be necessary.[8]

In the case of the child bitten by the dog, normal speech is paralyzed by fright and the conscious effort is begun in order to supply the deficiency. The failure of this conscious effort engenders an idea of speech disability, and the efforts are continued in order to overcome the difficulty; but since those efforts constitute the actual obstruction the affliction remains and fastens itself on its victim with hooks of steel. Every origin of stammering is embraced by the speech-interference theory; and conversely all alleged origins not embraced by it are false. Inheritance is one of the alleged origins which disappears and Freudianism is another. Lest someone claim that the failure of the theory to embrace these alleged origins is a weakness of the theory, the claim may be anticipated by the statement, perfectly tenable in scientific procedure, that no valid proof of these origins has ever been presented: scientists accept nothing until it is proved.[9]

In regard to the fallacies of the alleged proofs of inheritance and of Freudianism as applied to stammering see "Stammering and the Evidence of Its Inheritance," SCIENTIFIC AMERICAN SUPPLEMENT, No. 2203, March 23, 1918, p. 186; and "Stammering Discussions," *Journal of Abnormal Psychology*, Vol. XII, No. 4, October, 1917, p. 260. Fletcher can certainly not be considered biased in favor of the speech-interference theory for he is on record as rejecting it flatly. The bibliography to which he refers us includes 96 books on stammering, so he may be considered to have encountered most of the alleged proofs of inheritance. Yet he says, "The facts so far known seem only to warrant opinions rather than definite conclusions regarding the inheritance of the defect; and the opinions differ.[10]

Probably one more illustration of the sufficiency of the speech-interference theory will be sufficient to convince all who are open to conviction.

WHY STAMMERING DECREASES IN OCCURRENCE WITH ADVANCING AGE—SUBSEQUENT TO THE PERIOD IMMEDIATELY FOLLOWING SPEECH ACQUISITION

This test is of an omnibus nature, for it not only strengthens the speech interference theory but it also sweeps away all the other theories. Stammering is overwhelmingly an infantile disorder.[11]

When the supporters of the current theories could tie the defect down to the infectious diseases of childhood and to inheritance, they could argue plausibly that the absence of these in old age would account for the rare appearance of stammering in old age. But inheritance is off the list—it was never on the list by right—and the infantile diseases appear only as inducers of conscious efforts at speech, and not as elements of the disorder; so the supporters are obliged to try to fit their theories to conditions which maintain in advanced age even more than in childhood. Do dogs bite children only? Do not old folks fall down? Does nervousness occur less frequently in advanced age than in childhood? Is not aphasia more prevalent during advanced age than in childhood? Is insanity less prevalent with the aged than with the young? In the answers to those questions the innumerable "deficiency" theories melt away like snow.

[7]News report: Kansas City, Mo. The court of appeals has found that skinned knees caused Reed Kincaid, 16 years old of St. Joseph, Mo., to stutter and has affirmed the verdict of the Buchanan County court, awarding him $1,000. The judgment was against a laundry in St. Joseph. The boy worked for the laundry. His trousers were caught in the machinery and his knees skinned. The injury affected his nerves and impaired his speech.

[8]Rudolf Denhardt gives the history of a case which might be a technical exception to this rule, but the case is singular and it involves so many fine points that the casual reader would probably be wearied by a discussion of them. The interested reader is referred to "Das Stottern Eine Psychose," p. 115.

[9]"In the court of natural knowledge nothing is acceptable without proof. Gregory, "Discovery," p. 39.

[10]"An Experimental Study of Stuttering," *American Journal of Psychology*, April, 1914, p. 203.

[11]" . . . en règle générale, le bégaiement apparait dans le premiere enfrance, de 3 à 7 ans, quelquefois un peu plus tard, mais très rarement apres l'âge de dix ou douze ans." Le Docteur Chervin, "Bégaiement," p. 146.

Giving Medicine to Trees*

Fighting the Chestnut Blight by Injections of Curative Chemical Solutions

By Dr. Caroline Rumbold

Pathologist, Bureau of Plant Industry, U. S. Department of Agriculture

CAN a tree be cured of a disease by giving it medicine internally? The usual method of combating tree diseases is through the external application of sprays and fertilizers, or by cutting out and burning diseased parts of entire trees. Many parasitic fungi grow so deeply underneath the bark of a tree that any external treatment is ineffective. This is the case with chestnut blight, or the chestnut bark disease, as it is more properly called. When this fungus began to kill chestnut trees by the tens of thousands about fifteen years ago, it was not unusual for an owner of a prized ornamental chestnut to offer a reward of a thousand dollars to anyone who would save the tree. Numerous quack "tree doctors" advocated various alleged remedies which failed miserably when tested. Careful experiments by plant pathologists also failed to develop a successful method of saving a tree after it was attacked by the blight. The disease advanced ruthlessly and all who valued the chestnut trees were in despair.

In 1911, the State of Pennsylvania appointed a special commission to conduct scientific investigations to determine the cause of chestnut blight, and at the same time immediately to attack the epidemic by every means that seemed to afford any possibility of checking or delaying it.

In connection with the other lines of experimental work carried on by this commission, the writer was employed to investigate the possibility of controlling the disease by injecting chemical solutions into chestnut trees. In 1913, the Pennsylvania Chestnut Tree Blight Commission advised the Governor to discontinue its work because the blight had advanced too far into the State to make control practicable with the appropriation available at that time. During the next two years the writer continued the injection experiments under the direction of the Office of Investigation in Forest Pathology, Bureau of Plant Industry, United States Department of Agriculture. The University of Pennsylvania furnished laboratory facilities and many supplies.

METHOD OF INJECTING SMALL TREES

The chestnut trees in this orchard were infected with the chestnut blight, and it was desired to find if the fungus under the bark could not be killed by chemicals, without injury to the tree. As the tree absorbed the solution it was siphoned out of the jar suspended from an upper branch and through the tube.

The credit for continuing these experiments to their present stage is due to Mr. Harold Pierce, formerly Secretary of the Pennsylvania Chestnut Tree Blight Commission, who generously financed the work.

The problem has been to find a chemical agent which would kill the fungus that causes the blight, when a solution was introduced into a tree. The first difficulty encountered was in getting the tree thoroughly injected with any kind of liquid. The sap of a tree does not circulate like the blood of an animal. The wood of a tree contains numerous vessels, or tubelike cells, through which the crude sap is conducted to the leaves to be manufactured into food which returns to the roots and other living parts through the inner bark. A substance in solution follows a vertical path up the tree through those vessels in the sapwood that are close to the place of injection.

By the same token it can also descend through those vessels, but in all of this there is lacking that persistent passing and return of a stream, such as the blood stream, which constantly bathes the cells of the animal body. This path in the tree through which the injected solution passes, usually is but little wider than the hole through which it is injected. Besides this, the walls of the tubular cells act like blotting paper, with the result that the farther the solution passes from the point of injection, the weaker it becomes. So in order to inject a tree evenly on all sides, it is necessary to make a number of injections on different sides of the trunk, and even on the limbs. This means that many quarts of a very dilute chemical solution must be put into a tree if the chemical is to reach all portions of the tree. Were one to use only a small amount of concentrated solution, it would kill the cells of the tree near the injection hole and would not reach other parts. This is one of the reasons why boring a hole in the trunk and filling it with strong chemical in either solid or liquid form is not likely to benefit a tree.

It was found to be essential to make the holes through the bark for injection purposes under cover of a liquid. If air enters before injection or with the solution, air-bubbles will clog the small tubes or vessels in the vascular bundles and prevent the solution being absorbed by the tree. The reader will probably ask at this point if a tree whose trunk is peppered with injection holes is not seriously injured by such treatment. As a matter of fact, the trees with which the experiments were made did not suffer from this cause. The injections were made under sanitary conditions and only small holes were made. These were afterward filled with clean grafting wax, and a callus growth quickly closed up the wound, forcing out the wax plug. By the end of three years, there was not even a scar to show where the injection had been made.

The idea of introducing chemical substances into plants is more than two centuries old. The first report on tree injection for purposes of medication was published by a Russian

*Reprinted from *American Forestry*, June, 1920.

INJECTING CURATIVE CHEMICAL SOLUTIONS

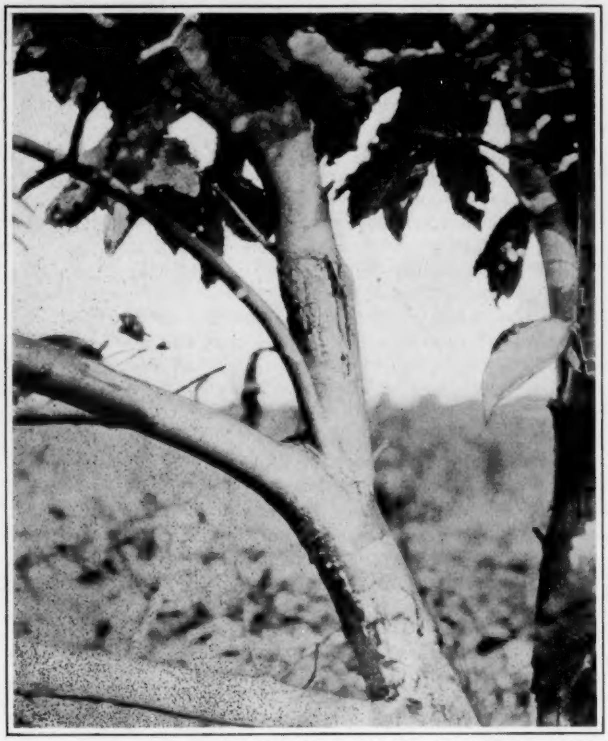
Another view of the apparatus used in injecting solutions into a trees, to enable the chemical solutions to reach all parts of the tree. branches and connected by rubber tubing with a glass tube inserted in a small hole made through the bark of the trunk. This hole in the bark had to be made under cover of a liquid, otherwise air clogged the vessels of the wood and the solution would not be drawn into the tree. A clamp held the glass tube tightly against the tree.

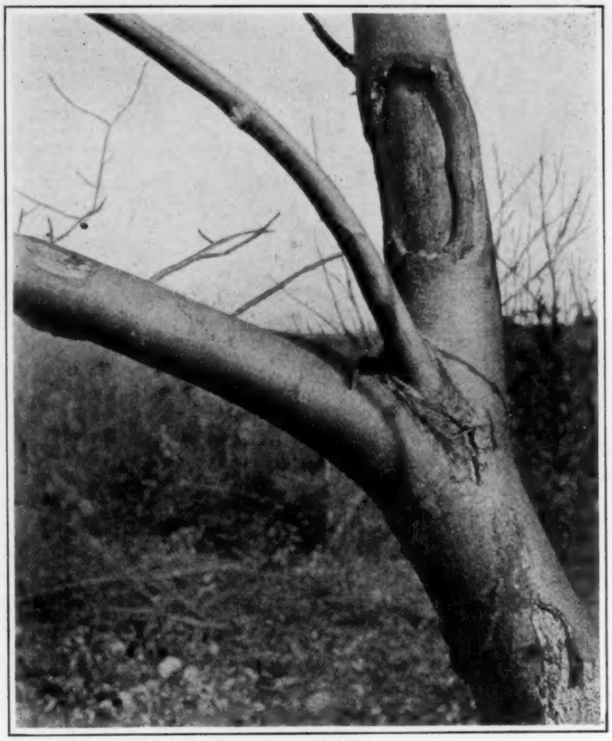
scientist in 1894. This was followed by scattered work in America, France, Germany and Russia. Some successful results were reported, but in the main the effect of injected solutions were not beneficial or the results were inconclusive. The most practical method was contained in the Russian publications, and the Russian method of introducing solutions was used in the beginning of the chestnut experiments. Very soon however an easier and less expensive method was developed, in which the apparatus could be quickly adjusted to the trunk and left for twelve hours or more without further attention. On small trees, a glass container holding the solution to be injected was hung on a branch of the tree. The solution was led to the point of injection by a rubber tube in the end of which was a piece of small glass tubing which was inserted into the injection hole. The glass tube was held in place by means of a perforated rubber cork, which in turn was pressed tightly against the tree trunk by a clamp, thus preventing leakage. This apparatus is shown in the accompanying illustration. A variation of this method was used on large trees. In place of the clamp, a link chain was placed around the trunk. It was tightened by turnbuckles and held the perforated rubber corks against the tree. The corks were protected from the metal chain by iron washers. A glass "T" tube, thrust through the cork, introduced the solution into the injection hole. The rubber tube leading from the reservoirs higher in the tree was attached to the vertical end of the "T" tube. The free end of the horizontal arm of the "T" tube was tipped by a piece of rubber tubing; after the solution filled the tube, a tempered steel cutter was inserted through this horizontal arm of the "T" tube and driven through the bark of the tree. In this manner a small hole was made in such a way that no air could clog the vessels of the wood, and the solution to be injected began immediately to enter the tree. After the steel drill was removed, the free end of the rubber tubing was closed by a pinch cock. By this method any desired number of injections were made at one time. In these experiments, the hole cut for injection purposes was one-fourth inch in diameter and penetrated the wood to a depth of two annual rings.

It was found that all kinds of chemicals in solution could be introduced into the trunks, provided there was sufficient transpiration (evaporation of moisture) from the leaves to keep the sap moving. The transpiration was greatest in the case of chestnut trees when they were in full leaf and the day was sunshiny, dry, and a breeze was blowing. On cold, rainy days the trees took up very little of the injected solutions. The season of the year caused a great variation in the amount of solution absorbed by a tree, and also as to the part of the tree where the injected chemical went. For instance, if a lithium solution was injected in the autumn, when the nuts were ripening, a large amount of lithium collected in the fruits and in the ends of the fruiting branches. In the early spring, when the leaves were unfolding and growing, the lithium spread through the tree and less of the chemical reached the leaves. In Pennsylvania, June was the best month for injection so far as the rate of intake was concerned; then July, May, August, September, October and April. The rate of intake varied more in April, May and June than in the summer and autumn months. Solutions of organic compounds went into the trees more readily than solutions of inorganic compounds, and the "true solutions" more readily than the colloidal. The average amount of solution absorbed through a single injection hole by an orchard chestnut tree, 15 feet high and with a wide, rounded top, ranged from one-fourth pint per day in April to three-fifths pint per day in June. But there are records of three and nearly four quarts of solution passing through an injection hole one-fourth inch in diameter in 20 hours. Chemical solutions with very few exceptions, were absorbed more readily than the pure water. Also, the more concentrated the solutions of chemicals, the more rapidly they were absorbed. In several cases, lithium injected into the trunk could be de-

TREATMENT FOR LARGER TREES

A number of injections had to be made at one time in the larger trees, to enable the chemical solutions to reach all parts of the tree. This illustration shows three glass containers hung in a chestnut tree, and a chain clamp that was used to hold the tubes in the holes made through the bark. On a clear day in midsummer a tree of this size absorbed many quarts of solution.





CHESTNUT TREE IN WHICH LITHIUM CARBONATE HAS BEEN INJECTED

View at the left shows the drying up of the chestnut blight canker. The dead bark was easily lifted out because the fungus was killed by the chemical. *View at the right* shows the same canker with the dead bark removed, exposing the healed up edges of the blight canker. A year later this tree had thrown off the chemical and had become reinfected. However, this experiment indicates interesting possibilities for controlling tree diseases by injected chemicals. That will destroy the fungus without harming the tree.

tected 10 hours later in the leaves of branches at the top of the tree.

Fifty-six organic and inorganic substances in solution were injected. The trees used in the experiments were orchard trees, for the most part Paragon scions grafted on native chestnut stock, but some trees growing under forest conditions were also injected. Most of the trees were already infected with the chestnut bark disease. The cankers were outlined with paint at the time the chemicals were injected into the trees, so that an accurate record of the effect of the chemical on the fungus was obtained. The war interrupted this work before it had gone further than to show interesting indications. In the case of diseased chestnut trees injected in the spring and early summer months with dilute solutions of lithium carbonate and lithium hydroxide, the fungus causing the blight was checked in its growth and the trees started to form a callus at the edge of the canker. In some cases this callus growth resulted in so completely cutting off the diseased tissue from the rest of the tree that the diseased portion dried out and could be picked off like any other dead bark. However, the lithium was gradually eliminated from the tissues of such trees and they were then subject to reinfection by the disease. Thus, the success in controlling the blight has so far been only to find a temporary check.

The results of these experiments indicate that there is a large field for further research on the possibility of finding a cure by the injection method for chestnut blight and similar parasitic fungi that grow beneath the bark of trees. This work is preliminary only and has not solved the problem. It took many years of patient experiment to develop salvarsan, and this solved a problem as apparently hopeless as that of finding a practical remedy for the chestnut blight.

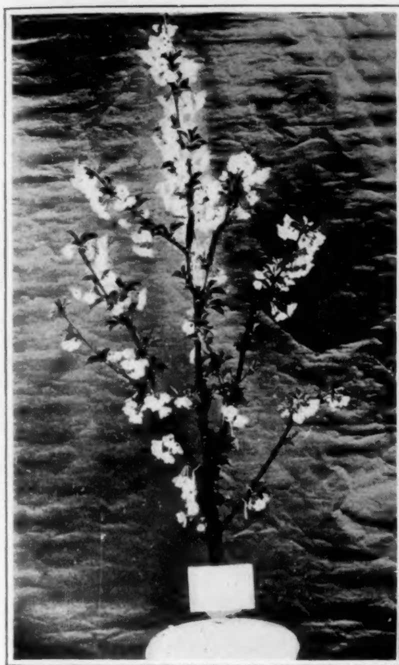
The subject is intensely interesting and will undoubtedly be further explored in the future. In the meantime, owners of chestnut and other valuable shade trees should know that itinerant "tree doctors," who claim wonderful curative powers for mysterious substances inserted into trees, are not likely to have been successful in achieving that which years of careful scientific research have failed to produce. This statement is not intended to reflect on trained men who are conducting legitimate tree surgery operations, but is directed against those "quacks" who prey on the ignorance of shade tree owners by selling worthless "remedies" at fabulous prices. Such persons not only get their money through fraudulent representations, but frequently cause death or serious injury to a valuable tree.

SYNTHETIC CAMPHORS

CAMPHOR customarily means a substance derived from a tree largely grown in Japan, China and Formosa. There are, however, several other kinds of camphor, but most of them are crystalline solids obtained from some plant. It has been known for many years that a camphor could be made from turpentine. Chemically speaking, camphor is a volatile oxygenated hydrocarbon.

It was not until the source of supply of natural camphor began to restrict its export and increase the price that American firms decided to engage extensively in the manufacture of a synthetic material. At the same time many camphor trees had been set out in parts of our southern states.

The great majority of the world's turpentine is produced in the United States and present conditions have advanced its price to 400 per cent over the normal, so that it is hardly to be expected that synthetic camphor can undersell the natural product at the present time. It is encouraging, however, to find that American chemists have devised methods that are commercially practical for the manufacture of this important gum independent of our foreign friends, and is but another indication of what could be done in our country with proper legislative encouragement. The progress that has been made is indicated in a recent bulletin of the American Chemical Society.



Courtesy, John Innes Hort. Inst.; Published in "Eng. Jour. of Genetics"

CHERRY TREE WHILE IN FULL BLOOM

All the flowers on the large branch at the lower left hand side were cross pollinated with a distinct variety. All other flowers were self-pollinated.

THE SAME CHERRY TREE IN FRUIT

Photograph taken from opposite side of tree. Not a single self-pollinated flower set fruit while the cross-pollinated branch produced a good crop.

PLUM TREE WHICH WAS COVERED WITH BLOOM

The different branches were fertilized with pollen from four different varieties. Three of these were wholly ineffective in forming fruit while with the fourth the tree bore abundantly.

Sterility in Animals and Plants

Hereditary Lethal Factors Which Stop Development When Received from Both Parents

By D. F. Jones

PLANTS and animals which are healthy, vigorous and apparently normal but are unable to reproduce their kind, are well known. One of the most disappointing experiences in the whole realm of gardening is carefully to nurse fruit trees through many trying years, guarding them against numerous natural enemies and vicissitudes of soil and season, only to have expectation defeated in the end because the trees are sterile with their own pollen. Many of the most prized varieties of fruits of various sorts are self-sterile and are unable to bear unless trees of other varieties are growing near by to furnish suitable pollen. For farmers doing a business with pure-bred, registered live stock inability to produce young in large numbers is sometimes a serious obstacle in the way of financial success. Although much less is known about the same phenomenon in man, infertility in matings where no pathological bar exists and where apparently there is no reason why children should not be, is one of the stern facts of nature which stand as a wrecker of human hopes.

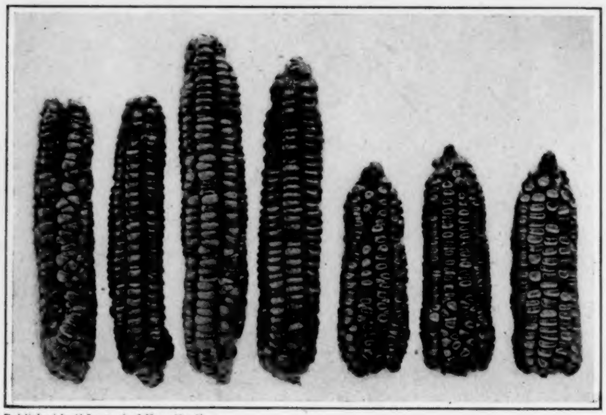
Sterility in both organic kingdoms is widespread and due to many different causes. Since procreation, from a purely physiological standpoint, is the most difficult task which any animal or plant has to perform, being the goal toward which all energies are directed and standing as a crowning achievement, all those factors which tend to impair life tend to reduce reproductive ability. Disease, directly or indirectly, may be an important agency in sterility. Food in excess or deficiency may work the same way. Radical changes in surroundings or mode of life produce this result, as many animals brought from the wild into captivity are notoriously infertile. Plants brought from one region to another sometimes fail to set seed. But leaving aside all these external influences of the environment which, to a certain extent, are controllable, there remains a large amount of sterility due strictly to heredity.

In this category there are two general types. In one the failure to reproduce is due to a degeneration of certain organs, tissues or reproductive cells representing a defect somewhere in the life processes which may be manifested at any stage during development from the time the egg is fertilized until the germ cells are formed ready for the next generation. Usually sterility is brought about by conditions which become apparent just before or just after fertilization. In the first case the organism is unable to produce reproductive cells. In the second certain combinations of sex-cells are incapable of development.

The most noticeable occurrence of sterility due to inability to produce viable gametes is in species hybrids. As is well known widely separated forms cannot be cross-fertilized, but as the degree of relationship becomes greater sexual union is possible but with difficulty and when hybrid forms are produced they are frequently sterile. The classic example is the mule, the result of mating a female horse with a male ass. Mules are not only normal animals in respect to ordinary life processes but are even more healthy and sturdy than their parental races. But these animals are unable to reproduce themselves. Microscopical examination shows that the tissues which ordinarily produce the sex cells undergo degeneration and no viable eggs or sperm are produced. Many other wide crosses in animals are known of which the males are completely sterile while the females are fertile. A new

type of animal the cattolo, which is a combination of cow and buffalo, was possible because the hybrid females were fertile and were bred back to one of the parental types.

Of greater practical importance are the widespread cases of sterility in pure races of animals and plants which have not undergone any hybridization, at least within recorded time. It is only recently that the hereditary nature of such instances has been clearly demonstrated. The past two decades have seen a notable advance in the study of heredity.



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EARS OF CORN WITH ABORTED SEEDS

An illustration of a hereditary lethal factor which stops development immediately after fertilization.

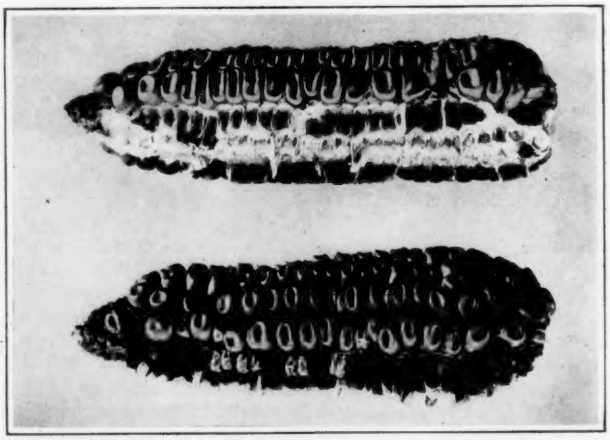
The chief result of this investigation has been to show that the inheritance is made up of units represented by something in the reproductive cells which, when given a suitable opportunity to develop, determine the peculiar characters of every individual, subject to a certain amount of influence from the surroundings. Thus flower color, seed color, form and composition of seeds, and height, in plants; and hair color, eye color, and coat pattern, in animals, as a few examples, are predestined very largely by these inherited units. Most of the character units, transmitted from one generation to the next and the combinations of which make the characteristic features of each individual, are concerned with only normal functions of the organism but a class of hereditary determiners are known which represent abnormal and defective germ plasm in that they stop development at certain stages whenever they are present in any individual in double dose, that is, when the same abnormal factor is received from both parents.

A good example of such a lethal factor, because it shows up in such a clear cut manner, is furnished by the corn plant. In the ears of corn which are reproduced in the accompanying illustrations a certain proportion of the seeds are aborted and these are scattered uniformly over the ear. All that remains in a shrunken mass or an entirely empty seed coat where normally a good seed would be produced. This state of affairs is due to a definitely inherited factor which stops normal development immediately after fertilization. Only those seeds which receive this deficiency through both the egg and the sperm are affected in this manner. Of the normal seeds on the same ears two out of three, on the average, have received only one dose of the mortality factor coming either from the female or the male side. Such seeds do not show the defective condition as the normal factor dominates the abnormal. They will grow and produce normal plants but they carry the same hereditary sterility factor so that when they come to produce seed in turn part of their progeny will be abortive. Because an inherited defect of this sort is covered over and obscured from sight it is able to persist from generation to generation showing up in a portion of the offspring every generation.

Similar lethal factors acting in the same manner are widespread in both animals and plants. Not all such determiners stop growth immediately after fertilization. Certain kinds may permit normal growth up to a certain stage at a point where some function should normally begin to operate, lacking this the organism fails to develop properly and shortly afterwards dies. Witness the inability to form chlorophyl, a definitely inherited deficiency in many plants, as illustrated here in corn. In animals many abortions are undoubtedly due to such lethal factors which behave in the same manner as shown by the defective corn seeds. Mice furnish a case which has been known for many years. The degenerate embryos stop growing and are absorbed very early in their prenatal life. In females which carry the sterility factor the abortive young are found by postmortem examination along with normal embryos. No clear cases of this kind have been recognized in the common domestic animals but it seems very likely that certain types of abortion and infertility, particularly in pure-bred livestock which has been closely inbred, are due to similar inherited factors. Close mating does not cause the sterility but brings about a condition in which recessive weaknesses show up in greater numbers if they are present in the stock. In this way consanguinity is a valuable means of detecting carriers of defective heredity.

The problem in animal breeding practice is to locate the normal transmitters of the deficient germ plasm. Of the progeny that contain the abortive individuals some will be normal and will never transmit the hereditary sterility while others of exactly similar appearance will pass on the undesired trait. Obviously it is of considerable economic importance to be able to distinguish between the two. The only way to do this is by the progeny performance record. All those individuals which produce defective offspring should be prevented from reproducing unless they are exceptionally valuable. If that is the case certain of their progeny will be free from the taint and with good fortune they may also possess the qualities desired to be perpetuated but many will still carry the sterility factor and should not be used as breeders.

It seems quite likely that the same state of affairs may occur in man although nothing positive is known. Reliable evidence is difficult to secure because the number of offspring in any one family is small and non-viable births and total barrenness are due to many causes. But recent workers in this field are convinced that a certain proportion of sterile matings and miscarriages, particularly those early in pregnancy, are due to hereditary lethal factors which absolutely prevent further development. If such is the case it is indeed fortunate that growth should stop as quickly as it does



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DEFECTIVE SEEDS PRODUCED ON EARS IN DEFNITE PROPORTIONS

They cannot grow but some of the normal seeds on the same ears carry the same hereditary deficiency which will reappear in their offspring.

rather than be prolonged until some later stage. At the present state of affairs nothing can be done to reduce the amount of this defective heredity and such cases, although they come within the physician's province, are clearly beyond the possibility of alleviation by medical practice.

Another type of sterility is more common among plants. It has long been known that certain trees fail to set fruit unless specimens of other varieties are growing near by. Apples, plums, cherries and many of the small fruits show this. Although the sterile trees are vigorous and perfectly healthy and bloom profusely yet they sometimes set not a single fruit because the pollen from the same plant or others of the same variety is incapable of fertilizing the flowers. Why the plant's own pollen is ineffective is not entirely clear. The failure comes in some physiological impediment which prevents the pollen tube from growing fast enough to reach the ovary before the flower withers and falls off.

This type of sterility does not have the abnormal features shown by the degeneration of embryos. Although the plants by themselves are impotent they are perfectly normal in every other respect and when suitable pollen is available they are frequently very productive. This phenomenon is widely distributed throughout the plant kingdom and is known to occur in at least one species of animals.

It was formerly thought that self-sterile individuals were perfectly fertile with any other member of the same form. Recent investigations have shown this to be not the case. With plants the self-sterile individuals fall into different groups such that within any one group the members are both self-sterile and cross-sterile. But a representative of any one group is fully fertile with a representative of any other group. Thus the mere fact of crossing does not mitigate self-sterility and it is clearly seen that such a condition is due to certain definitely inherited complexes and only when the proper combinations are brought about does fertility result. Thus the possibility of changing from sterility to fertility by external treatment is relatively slight.

Nature has developed many means to insure cross-fertilization between different plants of the same species such as ripening the pollen and ovules at different times, placing the two sexes on different individuals and by floral contrivances which hinder the pollen being placed on the stigmas of the flowers from which it came but favor its deposition on other

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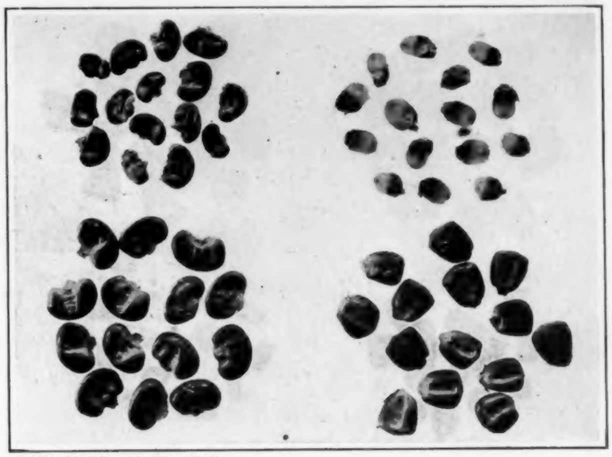
INHERITED LETHAL FACTOR WHICH STOPS GROWTH IN EARLY SEEDLING STATE

The white plants lack chlorophyl and, being unable to manufacture food, cannot grow beyond the stage made possible by the food stored in the seed.

flowers. The means by which the transfer of pollen is brought about furnish some of the most interesting features in plant life. Sterility of the type of incompatibility with the plant's own pollen but perfect fertility with foreign pollen is one of the means employed by nature to insure cross-fertilization and as such has undoubtedly played a part in evolution.

However that may be it is most disheartening for the amateur horticulturist to find his favorite trees, from which he has expected so much, wholly barren. Fortunately this state of affairs can be prevented by taking care that the right kind of varieties are planted together. In case this very necessary provision is not made grafting can be frequently resorted to so that by inserting cions from compatible varieties into some



Published in "Journal of Heredity"

ABORTED SEEDS COMPARED TO NORMAL SEEDS FROM SAME EARS

of the branches of the sterile tree, flowers with suitable pollen can be produced more quickly than by waiting for young trees to be grown to flowering age.

Although information in regard to such a lack of affinity between reproductive cells comes largely from plants at least one instance is known of a hermaphroditic sea animal which is self-sterile. Eggs of this species when put into water which contains sperm from the same individual that produced the eggs are unable to develop. But fertilization takes place readily when the sex cells from other individuals are present. Even though evidence is lacking it is expected that it will be found that self-sterile animals like plants will fall into groups the members of which are intrasterile and inter-fertile. Having been demonstrated, this would throw considerable light on puzzling cases among higher forms where individuals which are perfectly healthy and produce viable reproductice cells are incapable of procreation in certain matings yet both are fully fertile in other matings.

PLANTING WHOLE POTATOES INSTEAD OF "EYES"

It has been the immemorial custom to cut seed potatoes into fragments so as to make them go as far as possible, all that is necessary being that each fragment should have an "eye." A French authority, Aimé Girard, claims however that a better yield is obtained if the whole potato is planted, and he advises against the use of small potatoes, moreover. Some species however, lend themselves to the use of fragments better than others according to Henry de Varigny, writing in *La Bibliotheque Universelle* for April, 1920. He cites an experiment made in 1917 in a military field where the "seed" consisted merely of vegetative tops, i.e., of fragments one or two centimeters thick. These scraps were those obtained during the peeling of the potatoes for culinary purposes. They were immediately placed in dry sand in order to keep them in good condition until they could be planted. The results obtained with this very economical supply of "seed potatoes" were excellent, yielding a harvest of about 10,000 kilos per hectare. However, the crop was cultivated under very special conditions. Each potato was exposed to the full daylight for a month; a piece of the potato was then cut off weighing not less than 45 grams and containing two vigorous and healthy sprouts.

FIGS. 1 TO 3. A HYPHA OF *PYTHIUM DE BARYANUM* PUSHING THROUGH A CELL WALL BARRIER

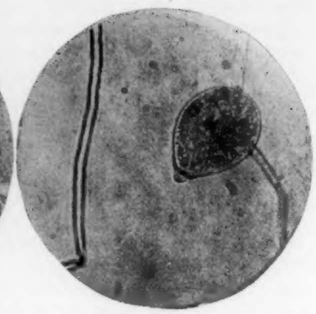


FIG. 4. *PHYTOPHTHORA* SPORANGIUM ABOUT TO GERMINATE

Some Enemies of the Potato

Interesting Methods of Dispersal of Some Parasitic Fungi

By R. B. Harvey

Physiologist, Bureau of Plant Industry, U. S. Bureau of Agriculture

PARASITIC fungi, which are of economic importance on account of their injurious effect upon various food crops, are spread in a great variety of ways, only a few of which can be considered here. The means of dispersal most commonly thought of are those in which the fungus itself takes only a passive part, the active element being some other agent. For instance, birds carry fungus spores upon their feet for long distances. For shorter distances, insects, domestic animals, railway cars, and in fact anything that moves from one place to another may aid in the spread of such organisms. The spinach plant louse is a carrier of the virus of the mosaic disease and spread of the disease may be limited by controlling the insects in the spinach fields. Biting insects spread the infection (*Bacillus tracheiphilus*) of the wilt disease of members of the cucumber family. In many such cases the infectious material is carried by the insect in its digestive tract. The majority of fungi have some form of resistant stage in their life cycle (spores, etc.), in which they are capable of undergoing prolonged cold and drought. This is the stage in which a great number of fungi are disseminated. The spores are blown about by the wind or carried away by rains to infest new areas. During the threshing season in the middle western states the "blower" threshers in use at present send up great clouds of the spores of wheat rusts and smuts which are carried by the wind for miles and are a continual menace to the wheat crop of the following year. In all of these methods of dispersal the fungus takes no active part in the dissemination.

Apart from these passive methods the fungus itself may take an active part in providing for its dissemination. This may be either by growth alone, for this must be considered a means of dispersal, or, by the formation of free-swimming spores called zoospores.

The phenomena of growth are of more importance in the spread of plant disease than hitherto has been recognized. In animals infectious organisms frequently gain access to a moving liquid medium, the blood stream, through wounds. Consequently there are no barriers to overcome and one thinks of the act of infection as being the important part of the disease dissemination. In plants there are no such means of spreading throughout the organism. Although many bacteria spread along the vascular system of plants, their dispersal by the liquids moving in these channels is of much less importance than in animals for the reason that there are numerous barriers, cell walls, interposed in the path. Passage must be gained through sieve plates or pit openings, each guarded by a living protoplast which must first be overcome. The cell wall surrounding each protoplast in the plants is often a sufficient barrier to prevent the spread of fungus. This barrier either must be removed by digestion through the secretion of extra cellular enzymes by the invading parasite, or it must be mechanically punctured. The latter method is limited of course to the filamentous fungi. An instance of the aggressive dispersal by the organism itself is found in the fungus *Pythium de Baryanum*, a destructive parasite which attacks various crops: the potato, cucumber, corn, white clover, and others. In greenhouses *Pythium de Baryanum*, which is called a "damping off" fungus, attacks many plants in the seedling stage. It enters the seedling near the surface of the ground and causes the plants to wilt down, each plant showing a characteristic shrivelled portion of the stem near the soil level. In the San Joaquin Valley of California this fungus does considerable damage to the potato crop. In this case it gains entrance to the potato tubers through breaks in the skin and causes a condition known as the "Leak" disease of potatoes. "Leaky" potatoes are recognized by the large quantities of juice which exude from them when shipped in the car—also by the smell.

The question as to just how the hypha of *Pythium de Baryanum* enters the plant has been determined by the author in a microscopic study of the living organism. The method used was to cut slices of potatoes three or four cells thick and inoculate them with the fungus. After a few hours at 30 degrees C. hyphae were found to be growing over the surface of the potato and the method of penetrating the cell walls could be watched under the microscope. The author has recorded several instances of the mechanism of cell wall penetration by cinematophotomicrography.

A hypha of *Pythium de Baryanum* is a small tube one ten-thousandth of an inch in diameter. It does not usually have cross walls and for this reason the growing hypha forms a continuous tube filled with living cell substance, the protoplasm. The stream of protoplasm moves continually toward the growing end of the fungus thread where it is transformed into cell wall substance, or is used up in cell nutrition. When the conditions are favorable this stream, filled with its granules of protoplasm, nuclei, etc., moves rapidly, reminding one of a river filled with logs and debris upon which one looks down as from a mountain. In motion pictures of the hyphae this resemblance is remarkable. The protoplasmic substances continually burst out by stretching the newly formed wall at the growing tip, forming a tube of the same diameter throughout. Thus the hypha by growth increases in length, this being an important means of spreading the infection. Waste products of hyphae serve as chemical stimuli directing the growth toward the periphery of the infection spot.

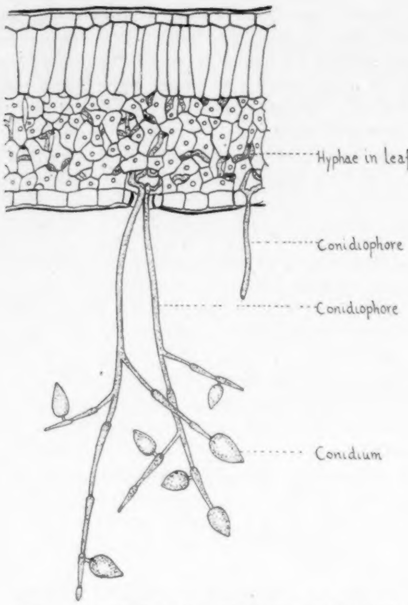


FIG. 5. SECTION OF POTATO LEAF AND CONIDIOPHORES OF *PHYTOPHTHORA*

In growing through potato tissue at its normal rate the *Pythium* hypha meets with a cell wall barrier about every twenty minutes, this being the average time required for the hypha to transverse the average potato cell 1/150 inch in diameter. It takes the hypha only five minutes to penetrate the cell wall. To the author this seemed to be entirely too short a time to account for the breaking down of the potato cell wall by a process of digestion. That process would involve the excretion of several kinds of enzymes, or ferments, a naturally slow process, for enzyme molecules are complex and diffuse slowly. Also, it has been found that *Pythium de Baryanum* produces enzymes which dissolve the pectinous substances which hold the potato cells together, but it does not produce enzymes which are capable of dissolving the celluloses of the secondary thickenings.

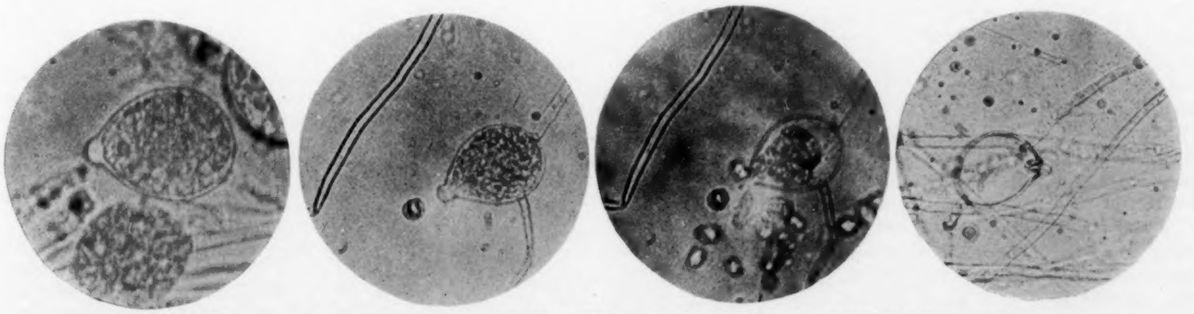
Good evidence has been obtained from observation and from photomicrographs secured on motion picture film, that mechanical breaking of the cell wall is an important factor in the spread of *Pythium de Baryanum* through potato tissue. In the photographs (Figs. 1, 2, 3) the hypha pushes against the cell wall by growth pressure so that the wall is bent in and may give away before it. The actual rupture of the potato cell wall is probably due to development of hydrostatic pressure against it after the fungus hypha has become cemented fast to it. The pressure required to break through the wall has been determined by using fine glass needles and a delicate spring balance. The osmotic concentration of the cell sap of the fungus is sufficient to develop the hydrostatic pressure required to break the cell walls of some varieties of potatoes, but other potato varieties have walls too resistant to be broken by the hyphae and these varieties are highly resistant to the "Leak" disease. From this it is seen that growth phenomena are important in the dissemination of the fungi and in this case that mechanical penetration of the wall is the determining factor in the spread of the fungus.

Some fungi are actively disseminated by the production of free swimming spores. These zoospores swim about in the moisture of the soil or in dew on the surface of leaves or stems. They have an active period of a few hours, which carries them well away from the old infection spot. They then settle down, form a new hyphae, and start a new infection spot, usually by penetrating the cuticle of the host or by entering it through stomata. Such free swimming spores have a very important limitation for their activity. They are absolutely dependent upon moisture for their dispersal. For this reason some of the diseases caused by them are limited in their dissemination to rainy periods. The zoospores are very sensitive to such poisons as copper. For this reason the use of copper sprays is an effective control measure against such diseases. The poisonous compound sticks to the leaf, going into solution in small amounts in each drop of dew on the surface. Consequently, when zoospores swim into such a solution they are quickly killed and dissemination of the infection is prevented. One good example of this practice of disease control by spraying is found in the "late blight" of potatoes caused by *Phytophthora infestans*.

The mycelium of *Phytophthora infestans* grows within the potato leaf and sends out branched portions (conidiophores) which protrude through the stomata into the open air. Egg-shaped masses of protoplasm called condia, or zoosporangia, form at the tips of the conidiophores. When mature conidia of *Phytophthora* come in contact with dew their protoplasmic contents quickly divide into several masses called zoospores. Zoospores are able to swim about by means of whip-like flagellae.

In the species of *Phytophthora* which causes a disease of rhubarb, the method of dissemination is much the same as in the above-mentioned case. One sees first, as in Figure 4, the normal granular protoplasm of the zoosporangium previous to the appearance of cleavage lines which indicate the approaching active stage of germination. In Figure 6 the tip of the sporangium is shown somewhat swollen and about to break. The protoplasmic contents are plainly seen to be collecting into divisions for the formation of zoospores. In Figure 7 the tip is just about to break open, and in Figure 8 the zoospores are actively escaping and swimming about. All this process occurs within a few minutes. The pore of the sporangium through which the zoospores escape is smaller than the zoospores. It is interesting to watch under the microscope (Fig. 9) these zoospores crawling out through the hole like little pigs wiggling through a hole in the fence. After swimming about for an hour or so these zoospores settle down, lose their flagellae and round up. They then send out a germ tube which may penetrate the rhubarb plant and start an area of infection.

Although the dissemination of diseases by zoospores is most



FIGS. 6 TO 9. STAGES IN THE GERMINATION OF THE SPORANGIUM OF *PHYTOPHTHORA INFESTANS*

common during wet periods, even then their spread may be kept in control by their natural enemies unless man in his agricultural operations has upset the normal balance. The rotifers, infusorians, and possibly other soil animalcules, are natural enemies of the zoospores. Each animalcule may swallow zoospores until it is fifty times its normal size in an hour or so. In fact, one of the infusorians, *Keronia*, has been observed to swallow a continual stream of the zoospores of *Physoderma zeamaydis*, a fungus which causes a disease of corn in the southern states during wet seasons.

Under conditions in nature undisturbed by man there is such relation between climatic conditions, the parasite, and its natural enemies, that a balance is kept much better than when man upsets some condition by his agricultural operations and thereby allows the spread of some disease to an abnormal extent.

GREEN PEAS AND SPINACH AS A TONIC.—CHLOROPHYL AS A BLOOD MAKER AND ENERGY PRODUCER

FOR the building of a molecule of haemoglobin, the chief essentials are albumen, iron, and four-membered pyrrol rings. These rings are present in the coloring matter of blood as well as in chlorophyll or green coloring matter of plants; on this account the question suggests itself as to whether the bodies of men and animals are likewise capable of producing them synthetically from the pyrrol-containing amino acids found in albumen (prolin and tryptophane) Emil Bürgi, writing in the *Therapeutische Monatschefte*, 1918, Nos. 1 and 2, discusses this question most interestingly. He begins by mentioning that according to the newest investigations of Willstaetter and his followers, the chemical relationship first observed by Menki between the green coloring matter of leaves and the red coloring matter of blood is not so close as was formerly observed, but that as regards the formation of haemoglobin out of chlorophyl only the pyrrol rings of the latter substance are concerned. Apparently blood is capable of forming blood, especially in flesh eating animals. Most human beings have a natural reluctance towards the taking as food preparations of blood and as a matter of fact such preparations never consist of pure haemoglobin or of haematine, and may, moreover, very probably contain injurious substances because of their plasma content. By an extensive series of experiments, made first with guinea pigs, Mr. Bürgi proved experimentally that chlorophyl possesses *the property of forming haemoglobin.* The guinea pigs were first reduced to an anaemic condition either by the loss of blood or by means of phenylhydrazin and were then given suitable doses of chlorophyl. It was found that they recovered the normal character of their blood as rapidly through the doses of chloropyyl as by the doses of iron ordinarily employed to relieve an anaemic condition. Their recovery was most rapid, however, when both chlorophyl and iron were given. When administered to animals which were anaemic chlorophyl made the blood richer in both red corpuscles and haemoglobin.

Dr. Bürgi next made clinical experiments. He found that when chlorophyl was used with a very small amount of iron, about one-third the usual dose, it was very effective as a curative agent, especially in cases of secondary anaemia and of chlorosis. The experimenter observed also that the chlorophyl exerted a very invigorating effect, which he does not believe can be ascribed purely to its faculty of producing blood. Further experiment showed that the green coloring matter gently stimulated the action of both the heart and the intestines, and it seems apparent that when the food contains chlorophyl it is better assimilated. This invigorating power of chlorophyl is exhibited not only in animals but in human beings. The symptoms experienced were an agreeable increase in the sensation of well-being, a feeling of greater energy and the disappearance of fatigue when the chlorophyl is administered for a few days. Most of these results were obtained with a special preparation of chlorophyl, called chloro-san-Bürgi, which has been widely employed in Switzerland for the last few years. Dr. Burgi also recommends that special care should be taken to have the daily diet rich in chlorophyl, in other words, in green vegetables, pointing out that most of our vegetables are very poor in their chlorophyl content. It is also particularly advisable to see that the daily diet of feeble and anaemic persons should contain not only preparations of iron but a liberal amount of chlorophyl.

DIFFERENCE OF POTENTIAL IN BIOLOGY

OF recent years an increasing amount of interest has been shown in the electric phenomena associated with the vital processes of living creatures, and all the more so since it has been understood how closely connected are electrical and chemical phenomena. Some highly interesting experiments along this line have been recently made by a French scientist, M. J. L. Pech. His conclusions as reported at a session of the *Société de Biologie* in Paris, March 13th, 1920, are as follows:

1. The differences of potential between organic tissues and the liquids with which they are in contact including even the blood circulating in the blood vessels of living creatures, are capable of being modified by the action either of certain physical agents or that of chemical agents or that of organic products.

2. Osmotic exchanges are capable of being modified by variations in the difference of potential between an organic tissue and a liquid with which it is in contact.

M. Pech gives the details of four experiments whose results led him to adopt the above conclusions.

All the measurements concerned were made by connecting the object experimented upon with the movable apparatus of a quadrant electrometer either of the Branly or of the Marcart type, having a difference of potential of 220 volts between each couple of quadrants. The connections were made by means of lines practically without capacity, without self-induction, and without contacts of variable electrical state.

Exp. 1.—A living carrot, i.e., one just taken from the ground and still capable of being transplanted, had its fleshy root immersed in water up to half its height, whereupon there was found to be a difference of potential between the water and the foliage of about 4 volts. This difference was increased to 8 volts by the action of ultra-violet rays and disappeared when 10 drops of nitric acid were added to each 100 grams of the solution.

Exp. 2.—Symmetrical muscles of equal weight were taken from a rabbit which had been freshly killed by the piercing of the medulla bulbe. When these muscles were immersed in distilled water they were found to increase in weight (the difference of potential between the water and the muscle being about 1.5 volts). This increase of weight was found to be greater when by combining sources of electric energy the muscle was rendered negative with respect to the water, whereas it was less when the muscle was positive with respect to the water. Exposure to a beam of ultra-violet rays raised the potential of the muscle with respect to the water and diminished the absorption of the water.

Exp. 3.—It was found that there is a difference of potential of 2 volts between the blood circulating in the auricular vein of a rabbit and the muscles of its thigh. This difference disappeared when the thigh was exposed to a beam of ultra-violet rays and this phenomenon was found to persist for a full hour after the exposure to the ultra-violet rays had ceased.

Exp. 4.—Tissues freshly taken from a white mouse just killed by the piercing of its medulla were placed in contact with the toxin of diphtheria, and it was found that a difference of potential of 4 volts existed between the tissues and the toxin. When anti-diphtheria serum was substituted for the toxin this difference of potential was reduced to 2 volts, while between the tissues and a mixture of diphtheria toxin with anti-diphtheria serum the difference of potential was nil; this difference attained 2 volts when this mixture was replaced by a mixture of diphtheria toxin and *anti-tetanus serum.*

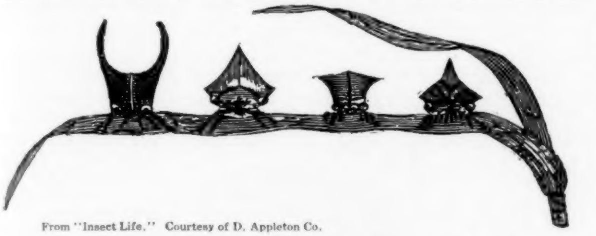
"Brownies" of the Insect World

Grotesque Little Creatures Known as Leaf Hoppers and Tree Hoppers

By May Tevis

AMONG the quaintest of the insects that people our world and compete with us for the provender provided by the plant kingdom, are those active little jumping creatures known as Leaf Hoppers and Tree Hoppers. The accompanying pictures show how grotesque some of these are in form. Among the principal ones are certain members of the Membrasidæ of the order Hemiptera, which are called more especially the Tree Hoppers and the Leaf Hoppers, the most important of which are the Grape Leaf Hopper, sometimes called the Vine Leaf Hopper, the Apple Leaf Hopper, the Rose Leaf Hopper, and the Frog Hopper or Frog Spit Hopper.

The word "hopper" is of course a popular term and is somewhat loosely applied, as might be expected. It is often used to include the lantern flies and it has been suggested



From "Insect Life." Courtesy of D. Appleton Co.

A GROUP OF TREE HOPPERS OR "BROWNIE BUGS"

that the latter be termed plant hoppers. All these creatures live on the juices of leaves and have sucking organs to obtain their food. By "leaf hoppers" we usually mean those which live on grasses and herbs instead of on trees or shrubs.

THE TREE HOPPERS

The Tree Hoppers live upon trees, vines and bushes and have as sprightly a gift of jumping as the flea. Many of them are curiously shaped, sometimes having camel-like humps on their backs and sometimes having horns like the one known as the Buffalo Tree Hopper, while in all the prothorax is prolonged so as to project like a roof over the body. The well-known entomologist, Professor John Henry Comstock of Cornell University, has aptly dubbed them the Brownie Bugs. In his book "Insect Life" he describes them as follows:

"If the young entomologist wishes to laugh, let him look at the faces of tree hoppers through a lens. A front view of several of these insect-Brownies is given in our picture. Their eyes have a keen, droll look, and the line that separates the head from the prothorax gives them the appearance of wearing glasses. In some cases the prothorax is elevated above the head, so that it looks like a peaked nightcap; in others it is shaped like a tam-o-shanter; while others have prominent horns."

THE LEAF HOPPER

Leaf hoppers are commonly found in pastures and meadows. The females lay their eggs in November in the tissues of the leaves and the young can be seen developing within the egg without removal. They are especially noticeable just prior to issuing by their jet black eyes. A few days after hatching the young leaf hoppers molt and the molt again twice thereafter, the full-grown individuals making their appearance December 22nd, giving a life period of forty-one days from the egg to the adult. The species seem to hibernate both in the egg state and in the adult condition and to have several generations each year. Osborn found the eggs inserted under the skin of the leaves of blue grass, making little blister-like swellings near the tips and causing them to turn yellow. Those which hibernate in the egg state issue in great numbers in grass lands early in May. There are two generations each year, the young being most numerous in late May and in August and the adults in June and in the fall. Large numbers have been attracted to the electric lights in Illinois.

Walking over our lawns or through pastures and meadows we often startle from the grass hundreds of small, usually greenish, little insects that leap or fly for a short distance, but soon settle again in the herbage. Nearly all these small and active insects are sap-sucking leaf hoppers of the family Jassidæ, one of the largest and most injurious of the Hemipterous families. It is stated by careful students of these grass-pests that from nearly one-fourth to one-half of all the grass springing up annually is destroyed by leaf hoppers. Professor Osborn estimates that over one million leaf hoppers can and often do live on an acre of grass-covered ground. These insects are rarely more than ½ inch long, and most of them are nearer half of that. The body is more slender than in the tree hoppers, and is usually widest across the prothorax or a little behind it, tapering back to the tip of the folded wings. The head is more or less triangular, as seen from above, and the face is oblique, sloping back to the base of the forelegs. The family is a large one, containing many species, of which several are well known to economic entomologists as special pests of grasses, growing grain, grapes, roses, etc. The injury is caused by the draining away of the sap of the plant by the host of little sucking-beaks thrust into its leaves or stem. Among the notorious destructive species is the destructive leaf hopper, *Cidadula exitiosa*, 1/5 inch long, brownish, which often injures seriously the winter wheat of the Southern States. Also the various grape-leaf hoppers which cause the leaves of grape-vines to wilt and turn brown and prevent the formation of full grapes; one of these, *Erythroneura vitis*, is about ⅛ inch long, crossed by two

THELIA BIMACULATA

blood-red bands and a third dusky one at the apex. "I have seen millions of individuals of *Erythroneura comes* in the great 3,300-acre vineyard of the Vina Ranch in the Sacramento Valley of California," says a well-known authority. "These leaf hoppers hibernate in the vineyard or about its

CAMPYLENCHIA (CURVATA) LATIPES

edges under fallen leaves and rubbish. Probably the best remedy for them is to keep the vineyards as clean as possible, or at least to burn up in the winter any accumulated rubbish." The rose leaf hopper, *Typhlocyba rosæ*, is often abundant on rose bushes, and also on apple trees. The eggs are laid in the summer, and the young develop through the summer and fall, hibernating as adults under leaves or rubbish. A common leaf hopper of grass fields is *Diedrocephala mollipes*, 1/3 inch long, spindle-shaped, grass-green above, pale yellowish below, with black lines across the face and top of head, and the fore wings with bluish veins and yellowish edges.

MEMBRACIDAE

The prothorax of the tree hoppers is variously modified and, in some of the tropical species, the modifications are very extraordinary. The young differ from the adults in being more normally shaped. Many of these young and some of the adults excrete "honey-dew," much as aphids do, and are eagerly attended by ants for the sake of the fluid. All of the species suck plant juices and the eggs are usually laid in the tissues of the food plants. Most of the species live on trees and low bushes, hopping vigorously when disturbed. They are best collected, says Dr. Frank Lutz, by beating them into an upturned umbrella, but the collector must act quickly or they will hop out again.

A synopsis of the genera, by Goding, is given in *Transactions of the American Entomological Society*, Vol. XIX. *Ceresa bubalus*, the Buffalo Tree Hopper, is often injurious to young orchard trees, especially apple, by reason of the scars made in the bark when the females lay their eggs. If a simple slit were made, it would not be so bad, but there are two slits at each place, crossing beneath the bark and so killing the intervening part. Most of the young leave the trees to feed on nearby weeds.

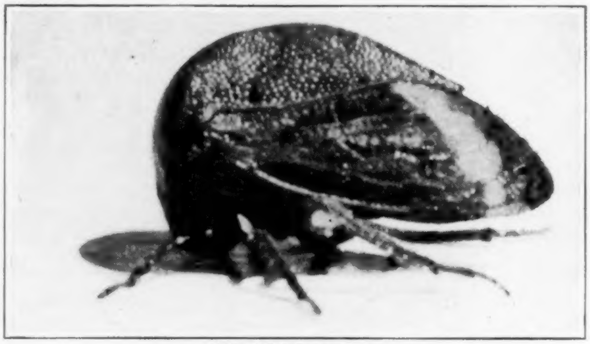
JASSUS OLITORIUS

FULGORIDAE OR LANTERN FLIES

The prothorax of the membracids is over-developed but the Fulgorids have excessively large heads. *Fulgora lanternaria* of the American tropics is an extreme type and one of the insects which is commonly sent to the American Museum of Natural History as a great rarity, according to Dr. Lutz. It illustrates the truth that weird-looking things are not always rare; it and some of its relatives have given the common name of Lantern Flies to the family. There are circumstantial stories concerning the luminosity of Fulgorid heads and categorical denials of these stories. "The Noes probably have it but, at any rate, the name sticks." Other species, such as *Acanalonia bivittata* have a more normal head and frequently look like small moths. Such species are often covered with an easily rubbed "meal" and, in the tropics, there are species which bear so many and such large filaments of a waxy substance that other insects live in the excretion. The eggs are supposed to be laid in plant tissues but although there are many species even in our region (New York)—more south of us they have not been well studied. Later authors split the family into a number of separate families or subfamilies.

CEROPIDAE

The Frog Hoppers or Spittle Insects get their common names by being broad, squat, hopping creatures whose young live in



CYRTOLOBUS SPEC

masses of white froth, sucking sap. "The spittle is a viscid fluid expelled from the alimentary canal of the insects and beaten up into a froth by the whisking about of the body. What advantage it is to the young insects is hard even to conjecture; it certainly is not known" (Kellog). Possibly it is a protection against drying out and it is said to harden into a protective shell when the insect molts.

OTHER LEAF HOPPERS: CICADELLIDAE

In the South the species of Leaf Hoppers which attack cotton have been named Sharpshooters and Dodgers. All of our numerous species are small and occur on vegetation of various kinds, especially grasses. Doubtless the small amount of sap taken by each of thousands of individuals amounts to a great deal per acre of grassland, vineyards and orchard.

Not all the injury done by these various forms of sucking bugs is obvious, and so used does the farmer become to the loss that very often he does not appreciate it. A simple experiment made by one of our economic entomologists proved that leaf hoppers in grass fields in his state were so numerous that they shortened the crop one-half. Demonstration of this was made by dividing a meadow into two equal parts, pasturing cattle on both, but collecting the leaf hoppers by means of hopper-dozers on one part only. This part supported exactly twice the number of cattle during the season that could be maintained where the hoppers were left undisturbed.

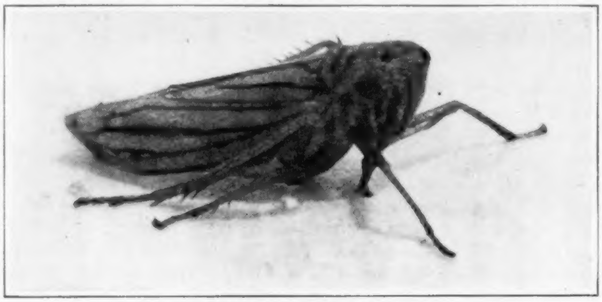
The New Jersey entomologist, John Bernard Smith, remarks: "It is comparatively easy for the farmer to estimate his loss when the green fly drains his wheat so that instead

DRAECULACEPHALA MOLLIPES

DELTOCEPHALUS INIMICUS

of the expected twenty bushels he harvests only ten or none at all. The drain upon all sorts of crops by the myriad of specimens constantly sucking plant juices and reducing the yield to a less obvious extent, is rarely capable of estimation, but varies from ten to fifty per cent almost every year on most of our staple crops. This sounds like an exaggeration, but every person who has ever studied the problem at all carefully will agree in the estimate, I think."

The hopper dozer is a sort of trap which is run over fields infested with leaf hoppers or grass hoppers and which gathers



FAGARONIA TRIPUNCTATA

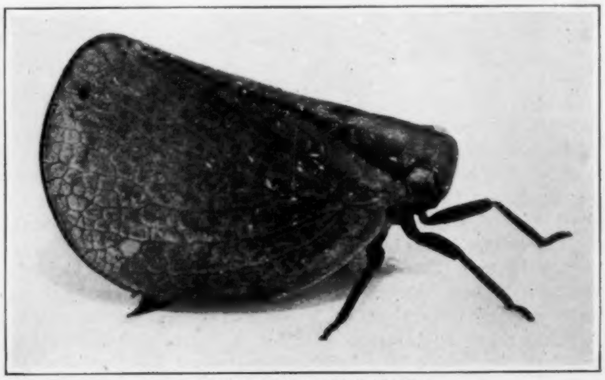
up the insects on a bed of soft tar or petroleum. It is operated either by horse-power or by man-power.

RECIPROCITY OF GROWTH IN THE TWO SIDES OF AN ANIMAL.

SOME very curious experiments are described in the *Naturwissenschaftliche Umschau*, the supplement of the *Chemikerzeitung* (Berlin) for January and February, 1915, concerning the symmetrical equilibrium between the two halves of an animal's body. If the bodily symmetry is disturbed by means of an amputation on one side, this equilibrium is, of course, disturbed. But it has been found that after a certain lapse of time this symmetry is restored by one means or another. If, for example, we clip both antennae, but at different points in the water flea, a small isopod, very common in fresh water (*Asellus aquaticus*), the shorter one of the injured antennae grows faster than the other, and the balance has been restored even before they have stopped growing. If only one of the antennae is cut off, it is regenerated but remains smaller and less differentiated. However, soon after the uninjured antennæ begins to atrophy. The same thing occurs when one of the nippers of a crab is amputated. In this case a smaller and toothless one grows out and at the next shedding of the skin the opposite claw likewise loses its differentiation and dentated condition. The larva of the water bug *Hydrophiles*, possesses two jaw bones each armed with two teeth; if one of these is removed it is regenerated, but without the tooth and when the shedding of the skin occurs the opposite jaw is likewise found to have only one tooth.

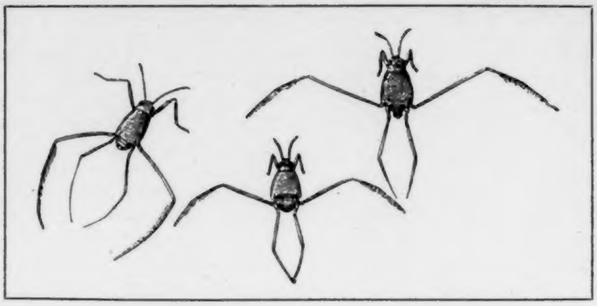
THE ONLY INSECT FOUND IN THE SEA

OF all forms of animated life the insects are those which are most abundant, not only upon the land but in the water, since a great many species are specially adapted to living near water and even spend part of their lives as water animals, as in the case of the larvae of mosquitoes. It is a singular fact, however, that the ocean which is so richly provided with such various forms of life, ranging from protozoa to the highest forms of warm blooded mammals, such as whales and seals, can boast of but a single insect. This creature is interestingly described by M. A. von Luetgendorff in a recent number of *Kosmos* (Stuttgart). The reason for the general absence of insects upon the surface of the sea is obviously, says this authority, the almost ceaseless and often violent motion of the masses of water, together with the general lack of plant life, such as might furnish sheltered dwelling places for insects. In view of these reasons it is all the more surprising to find that one species of insect has been able to adapt itself to life on the ocean waves. This is the seabug *Halobates*, closely related to the fresh water insect *Hydrometra*, the well-known "water runner." The structure of this little creature's body is admirably adapted for existence upon water in almost constant motion. Thus we see that while the *Hydrometra* possesses a comparatively long abdomen in the Halobates it has become so greatly reduced that the heart, intestines and organs of sex, which in other insects are contained in the abdomen are here found in the thorax. An examination of the insect at once shows the advantages which this structure possesses—on the one hand there is a smaller weight to be borne by the surface of the water and on the other hand is an entirely free motion of the rear pair of legs, which motion would be considerably interfered with by even a moderate sized abdomen. The middle pair and hind pair of legs are ideal members for swimming purposes. The middle pair is also provided with finer but more abundant and longer hairs at their ends. The object of this fringe of hairs becomes obvious when the insect is seen in motion, since the hairs and the air entangled in them increase the surface of the legs and of the body and thus make it easier for the insect to run over the surface of the water. The fore pair of legs, on the



ACANALONIA BIVITTATA

other hand, are much shorter and stronger and are fit less for swimming than for the capture of prey, they also have stronger claws by means of which the insect is able to seize its victims. Just what the "sea-bug" eats is still, however, quite uncertain. The head of the insect is well shaped with large eyes and moderately long antennæ. Certain peculiar hairs are possibly, in the opinion of Dahl, the organ of some unknown sense. The body of the insect is about 3 millimeters long and is usually of a moderately dark even gray tone, while its hairy underside has a silvery white gleam like that of many fishes. The legs sometimes have a bluish steely tint.



a *b* *c*

THE ONLY INSECTS FOUND IN THE SEA

This insect of the sea was first discovered in April, 1816, in the southern tropics by the entymologist, Ivan Eschsholtz, who was acting as ship physician upon the expedition sent out by the Romanzoffs. Some fifteen kinds of the *Habolates* are known which exhibit slight differences in color, etc. They are found exclusively in the tropic seas in comparatively calm stretches of water and can be best observed on days when there is little or no wind. They usually prefer the high seas to the vicinity of the coast, which is readily understood when we consider how helpless creatures so neatly designed for life upon the water would find themselves when by accident thrown upon land. At *a* in the accompanying engraving may be seen the *Halobates germanus*, while *b* and *c* are respectively male and female specimens of *Halobates micans*.

MAKING THE CORMORANT EARN HIS LIVING

ONE of the birds most widely found in nearly all parts of the world is the common cormorant. And wherever he is found he is noted and notorious for his voracity. Since the word comorant has become a synonym for greed the big dark birds are not by any means popular.

CHINESE FISHERMAN AND HIS TRAINED CORMORANTS RETURNING FROM A FISHING TRIP ON THE YANTZE KIANG

The Chinese, however, have been clever enough to turn this very trait of greediness to their own advantage. For many years it has been the custom in China regularly to breed and train cormorants to catch fish for their masters, just as falcons in the Middle Ages were trained for the hunt. The birds are so expert that they are considered very profitable, so much so that the government regularly taxes them. While the cormorants in China are bred and reared in captivity, it is customary to set the eggs under a hen. A properly trained cormorant obediently dives at the bidding of his master and promptly lays the fish he has caught at his master's feet. Perhaps he is assisted to be on his good behavior by the fact that there is a band slipped about his neck fitting sufficiently close to prevent the swallowing of the scaly dainty. But he knows that at the end of the catch this band will be removed and he will be liberally fed from the less choice portions of the catch.

Doolittle says that the bridges of Fuchow are often crowded with spectators enjoying the exhibition of the birds' skill. The fisherman stands upon a raft, about 90 centimeters wide and from 5 to 7 meters long—this raft is made of bamboo and moved by an oar. The fisherman throws or pushes his cormorants into the water and if they fail to dive he either beats the water smartly with his oar or inflicts punishment on the lazy birds therewith. When the cormorant catches his victim at a considerable distance from the raft, his master makes haste to reach him, especially if the fish taken is large and is putting up a gallant fight to get away. When near enough he casts over the big bird and its victim a pouch-shaped net attached to a pole, not unlike a big butterfly net, and draws them in. Sometimes an unruly bird tries to fly off with his prey and occasionally succeeds. Brehm tells us that occasionally when the cormorant tackles a fish, which is evidently too big for him to manage, several other birds will hasten, not to the rescue, but to dispute the booty; whereupon a very pretty row occurs among the birds to the enthusiastic delight of the spectators.

Cormorants are by no means unintelligent birds. They are very cautious and suspicious of possible enemies. A curious story which bears witness to their intelligence is to the effect that when captive they will make use of pelicans, their fellow captives, to break the ice which chances to cover the pond in their enclosure. They do this by getting behind the bigger birds and nipping them and teasing them until one of them is forced to break a path in the ice to get away from his tormentor. Then the wily cormorants can enjoy the water in the wake of their feathered ice breaker.

ULTRA - VIOLET LIGHT AND PLANTS

A JAPANESE chemist named Tsuji is reported in the January number of *Chimie et Industrie*, as having demonstrated with great accuracy the relations which exist between ultra-violet rays and the formation of carbohydrates and other compounds in the banana, the pineapple, and the sugar cane. He has made the interesting discovery, furthermore, that ultra-violet rays obtained from the quartz mercury lamp are much more energetic than the rays from the sun. He states, in fact, that by the use of this lamp the period of 20 months, normally required to grow a crop of sugar cane can be reduced to 12 months. However, the cost of furnishing such an irradiation of the crop is not taken into consideration.

Geography in Industry and Business*

The Need of Geographic Training if America Is To Hold Its Place in the Commercial World

By J. Paul Goode

Professor of Geography in the University of Chicago

AMERICA today stands on the threshold of a phenomenal industrial and commercial opportunity. Our commercial interest in the outside world as measured in total foreign trade has grown in fifty years from less than a billion dollars per year in value, to over 12 billion. And from a rank of third among the great commercial nations, to first in rank. And yet we know that we are just fairly launched in foreign trade. Never in the history of the world was there such an opportunity for national expansion in world relations. And this is no idle boast. For we, as geographers, know the material resources, and geograhpic advantages, which underlie, which make possible, and which set the limits on industrial and commercial development. Let us, for one minute, run the gamut of these fundamentals, taking note of our share of the world's supply, and so get our bearings as to our opportunity for development in business.

I. TKE FUNDAMENTALS OF INDUSTRY AND COMMERCE

As we are all well aware, energy, power, is the most important single resource—the muscular power of men and beasts, or, what today is much more significant, the inanimate power of steam and electricity, given the world most largely through the burning of coal. Over half a century ago, Stanley Jevons said it best—"Nations with coal command." And if we add to coal, iron, copper, and petroleum, we have the four most fundamental and significant material resources of the modern world. Nations are powerful in industry, commerce and war just in proportion to their holdings of these resources.

Our opportunity for industrial and commercial development is measured by our wealth in these, and some other significant material resources. Let us recall, to get our advantages clearly before us, how large a fraction of the world's supplies we hold. Of the seven and one-third trillion tons of coal in the world, known and workable under present conditions, four trillion tons, over one-half of all of it, is within our borders. Moreover, we are producing now about half of the world's coal, half the iron, four-fifths of the copper, two-thirds of the petroleum, nearly half of the lead and zinc, about two-thirds of the aluminum, a quarter of the wheat, three-quarters of the corn, nearly one-half of the pork, and two-thirds of the cotton.

And with our enormous advantage in coal we are transforming these raw materials into finished product for all the world, and are concentrating our population in mushroom industrial cities—over one-half the total population there now —and these cities are calling on all the world for food, and for raw materials for their workers and factories.

At the beginning of the war the value of our foreign trade had risen to over four billion dollars in the year, one-half of which was export. The war has been very destructive to the trade of our nearest rivals, France, Germany, and Britain, while almost in equal measure our opportunities in foreign trade have grown, until now we find ourselves, at the close of the war, the leading commercial nation, with a total foreign trade almost twice as great as that of the greatest nation on earth in 1914, and with a very good prospect of holding the lead.

A sober survey of our advantages shows us our manifest destiny: to do the manufacturing and trade for half the entire world. Now these relations call for a large and intimate acquaintance with the peoples and problems of other lands. We are, willy nilly, an active member of the great family of nations. We can no longer stand aloof. We may not remain provincial. Our daily lives are shaped, and our prosperity waxes or wanes with the changing welfare of the nations who buy from us, or to whom we sell. It comes to be our daily need, as it should be our constant pleasure, to know the current progress of affairs in every quarter of the globe. That is, we have arrived at the time when our business men and their agents, by the legion, need a thorough grounding in geography as a part of an adequate education for business.

But as soon as we begin to specify the training for the individual merchant, the geographical requirement may widen out into a demand for research, it may be, of a most detailed and careful sort. For example, we are buying now over 80 per cent of the world's raw rubber. The demand for rubber far outruns the available supply. Merely to go as a merchant into the wilds of the Amazon and induce the natives to bring in gum, at the expense of killing the trees to get it, has got us nowhere, except in sight of the exhaustion of the source of supply. It is only when geographic research is made into the climate, soil, native labor supply, and transportation service, that regions on the other side of the world are found to be the hope of the future supply of rubber, so that now about three-fourths of the world's current supply of rubber comes from the realm of the rainy tropics of southeast Asia. There is no reason why the rainy tropics of the Atlantic margin may not serve also—and research is even now being called for to this end.

In many other commercial fields, the work of the trained geographer is going to be in demand. For example, the regions with coal are so rapidly developing a dense city population that the question of the food supply for industrial populations comes to be vital. The starches, the sugars, the proteins and the oils, must be found somewhere, and carried to the manufacturing populations. The largest undeveloped source of supply of these fundamental foods is in the tropics. Think of the profitable service the geographer may render, in solving the problem of the proper interrelations of climate and soil, as related to the best adapted crop—the source of labor supply, the sanitary requirements, the transportation service. Already sugar and tropical fruits rank among our most important imports, and we have just begun to develop the tropical trade.

This year our country will export goods to the value of about six billion dollars. How the foreign nations are going to pay for these goods, is a very serious problem to the traders and their bankers. In the long run, a nation cannot buy goods of a value much greater than that of the goods it sells. Then, too, so many of the nations are relatively undeveloped, that to produce the goods of which they are capable, requires new capital, to clear their lands, to develop their mines, to harvest their crops, to make roads and railways, and ports, and we must send them endless capital. Just in proportion as we furnish the capital, we will be in line to build their railways, and to sell them the manufactures they require. And think what a tax this puts upon the wisdom of our investors and bankers. They are in a position where they must know every relevant thing that may be known about the region where the investment is to be made. The information they want is exactly that which the geographer is anxious to supply. The relief of the land, the mineral resources, the soil, the climate, the natural vegetation, the most advantageous crops, the people, their number, their character, their ability as workers, their stability, the kind of supplies they may be interested in buying, the endemic diseases of the region which may stand in the way of commercial development, and the possibilities of improvement by

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scientific sanitation; the facilities for transportation by land, and by water. These things are typical of what the geographer is interested in knowing, they are exactly the things the banker and the investor want most to know. For a generation the German bankers, and foreign traders have insisted that the young men they send into foreign fields shall have had the special training of the technical trade schools, in which commercial geography is a fundamental study, and the young men going to a given region have been given a careful detailed training in the geography of the region. It is instructive to know that in the splendid development of the National City Bank of New York promising young college men are selected as apprentices for the foreign trade field, and to give them the definite training required in geography and some other branches the bank has established a school of its own, not being able to count on that training being given in our colleges as now managed.

II. GOVERNMENT CONTACTS WITH THE OUTSIDE WORLD

One thing the great war has demonstrated very clearly is, that the real prizes about which nations quarrel and governments come to blows, are economic prizes. The endless question is, who shall own the rich mines? who shall own the rich soils? who shall reap the economic reward of carrying the goods across the seas? It is when rich coal mines are demonstrated in Spitsbergen that the sovereignty of the islands becomes a live issue. It is when the Rand is proven rich in us, in our daily work, the geographer finds his opportunity to governments of South Africa go down to defeat before the great nation. It is the wealth of the oil wells, and the silver mines of Mexico which more than anything else brings political and social woe to our sister republic. It was the coal field of the north in France, and the iron mines in Lorraine which Germany coveted so keenly as to cause her to wreck her own career and bring endless woe to all the world. In all the new lands on earth the powerful hand of some strong government is more or less potently in the shadow of every merchant and every trade transaction. The more widely our merchants travel in extending their trade, the more intimately our government is brought into the affairs of other lands. It is the fashion in the world now for the government to assist her merchants, to look out for trade opportunities, to gather the information for the development of new fields, and to safeguard the merchant in his effort to extend his trade in foreign lands.

Our government is developing splendidly along these lines. The consular service is making a good record in observation of trade conditions. Commercial attaches are now at work in great commercial centers, and special investigators are working various regions, and industries, in the service of our manufacturers and merchants. But most of these men are not trained geographers, and to us who are working over their published material day by day, it is plain that there is much room for improvement: in the point of view; in the significance of the things observed; in the absence of observation on critical relations; in the interpretation of conditions recorded.

The development of our Shipping Board, War Trade Board, and War Industries Board during the war, furnishes a classic example of what geographic training is worth. In less than a year the merit of a good geographic foundation placed the three or four men who had it, into the top positions in the service, over the heads of many men who had spent their lives in the detailed business of foreign trade. And if the Government service in all these lines is ever to be put or kept at a high degree of efficiency, it will be because the geographic training is recognized at its true value, and required of all the candidates for such government positions.

III. OUR PRESENT LACK OF GEOGRAPHIC TRAINING

When we look around us in our own circle, to see what service geography may give to business, there is endless evidence of opportunity. The average business man is as innocent of geography as an egg is of hair. Nor is he different from his fellows. What little geography the antiquated, lop-sided school system permitted him to have he has forgotten. One prosperous merchant in the Stock Yards district was waited upon by our committee from the Foreign Trade Division of the Association of Commerce to get him interested in trading in Argentina or some adjacent state in South America. "Why," he said, "I'm doing a good business down there now. I'm selling a lot of goods to Australia. By the way, what part of South America is Australia in, anyway?"

Another merchant, only a few weeks ago, had a large order from Norway. He came to his banker with it, and the foreign trade man undertook to get the papers ready for him. The man called up the next day to say he had been thinking the matter over, and he didn't know as he wanted to *do* business with that blank bolshevist Russian state.

One merchant thought the Ukraine a new kind of breakfast food, while another thought it a musical instrument something like a banjo. And yet when the real geography is put before these men, they sit up and take notice. One of the men in our department is, as it were, specializing in Chambers of Commerce. He gives addresses on subjects in economic geography, or geographic interpretations of countries, or regions, or trade situations. The addresses are given in connection with noonday lunches. The dining room is packed. The usual audience is 500 to 1,200 men, the keenest, livest wires in our business world. And they invite him back year after year.

IV. THE NEED OF GEOGRAPHIC TRAINING IN BUSINESS IN THE HOME LOCALITY.

The interest in the wide world, and its business activities and opportunities is aroused, and the service of the geographer is beginning to be recognized in it. But we do not need to go so far afield to find all manner of occasion for the geographer's point of view, and his special research. All around us, in our daily work, the geographer finds his opportunity to serve developing business. And now business begins to look our way. For example, the management of various railways for many years have financed an effort to investigate the possibilities of development of the region served, and the publication of the advantages, to attract settlers and investigators. Usually it is true, a journalist has been chosen, because perhaps of his ability to turn out copy. Often the results have been patent floundering. Often the results have been open to the criticism of being a large collection of facts, most of which are not true. But some of the railway companies have arrived at the choice and support of trained geographers, whose investigations when made, have permanent value. Such studies as the classification of lands into categories of best service; the records of weather and climate, especially to bring out the particular advantages and hazards for given crops; the character and distribution of the natural vegetation, for example the forest resources, and the lands which may with profit be forested for future service; soils and locations inviting development for special crops; the water resources for power, for irrigation, and domestic use; mineral resources awaiting development, and many others.

Not only are railways looking for such men, but investment companies, and insurance companies are, likewise. One of our students is backed by an important northern railway company on such an investigation now, and another is undertaking a similar bit of research in the southern Great Plains area for investment and insurance interests. Other positions are looking for properly trained men, in vain.

One of the most important and promising fields of all is the City Survey being backed in various places by the Chambers of Commerce. These clear sighted business men realize that the city is a vortex of human activity, a flow of men and commodities from more or less wide tributary regions into the city, and a flow outward of men, and commodities more or less transformed. These commodities are destined for con-

sumption anywhere in the world outside, as chance may invite. The men who are interested in the growth of a city want to eliminate chance so far as possible. They want to know in detail all the factors of advantage which focus in a city site: convenience of access from the tributary regions, by road, by rail, by water; and improvements which may be made in all these transport facilities for the better communication with the outside world. They want an analysis of the best sites for factories and warehouses and for residence districts; studies indicating what the advantages are for various kinds of manufacture and trade; the source and character of the raw materials available; the labor supply and its housing, education and amelioration; the ways in which the city may best relate itself to the immediate region served by it; these and a hundred other lines of study make up the City Survey, a study which calls for experts in engineering, economics, and civics, but fundamentally geographic in the point of view, and in the correlation of the physical influences at work in the problem.

V. GEOGRAPHY OFFERS A WIDER HORIZON FOR A LIBERAL EDUCATION

The demand for the trained geographer is very much in evidence, in all the lines of business contact cited. And the demand is very complimentary to the pioneers among us who have been spending our lives in the development of the subject now coming into recognition. The evidence of a widespread general appreciation is shown in a very patent and significant way, in the election of geography courses in the colleges and universities where the new geography is offered. Such courses as commercial geography, agricultural geography, ocean shipping and trade, special regional courses in economic geography of North America, of South America, of Europe, of the Orient, and others. The instructors are swamped with students. They are coming in thousands, where they were in scores only five years ago. We hear of classes of 250 and 500 in the University of Pennsylvania, in Michigan and Wisconsin. And in Illinois, in Missouri, in California the record grows. In the University of Chicago there are this spring eleven sections of some of the earlier courses, where in 1914 there was one section. Of course, there is a handicap in this prosperity. Where the class runs beyond fifty, real teaching is impossible. The lecture system is resorted to with many quiz sections. But it is almost impossible to find men properly trained to handle these classes and to supply the business world with the trained men they require. For not only must the geographer be born, the real product is arrived at by years of study and drill, and only now and then can the able lad be found who can resist the attractive opportunities the very business offers him, whose problems he undertakes to study. Even the professors tried and true sometimes listen to these loud and urgent calls, and are lifted out of the "cloister" at salaries of $10,000 to $25,000 and an opportunity to do the research they have been getting ready all their lives to do, and be *paid* for it.

It is a serious handicap to lose these men from the list of teachers and research men. But even this dark cloud may have its silver lining, for it may result in putting the teachers of geography into different salary class; such a change as the teachers of medicine and law have already achieved, where the salary is such that a modest living is assured. It is time that the age-old idea should be revised—the idea that the teacher is one who is devoted to poverty and the instruction of youth.

We have always had a great admiration for the German geographers, who could go anywhere in the round world for the subject for a thesis; could work it up to the last detail, and publish it sumptuously. But we now know that the geography department in the University of Berlin was financed from the budgets of the Army and Navy, with the implication that the geography departments in other universities were likewise supported. That the government was glad to subsidize the geographers for the fundamental contributions they might make as bases of national strategy in trade and war. And evil and accursed as the German program was, that element of the subsidizing of research is most commendable.

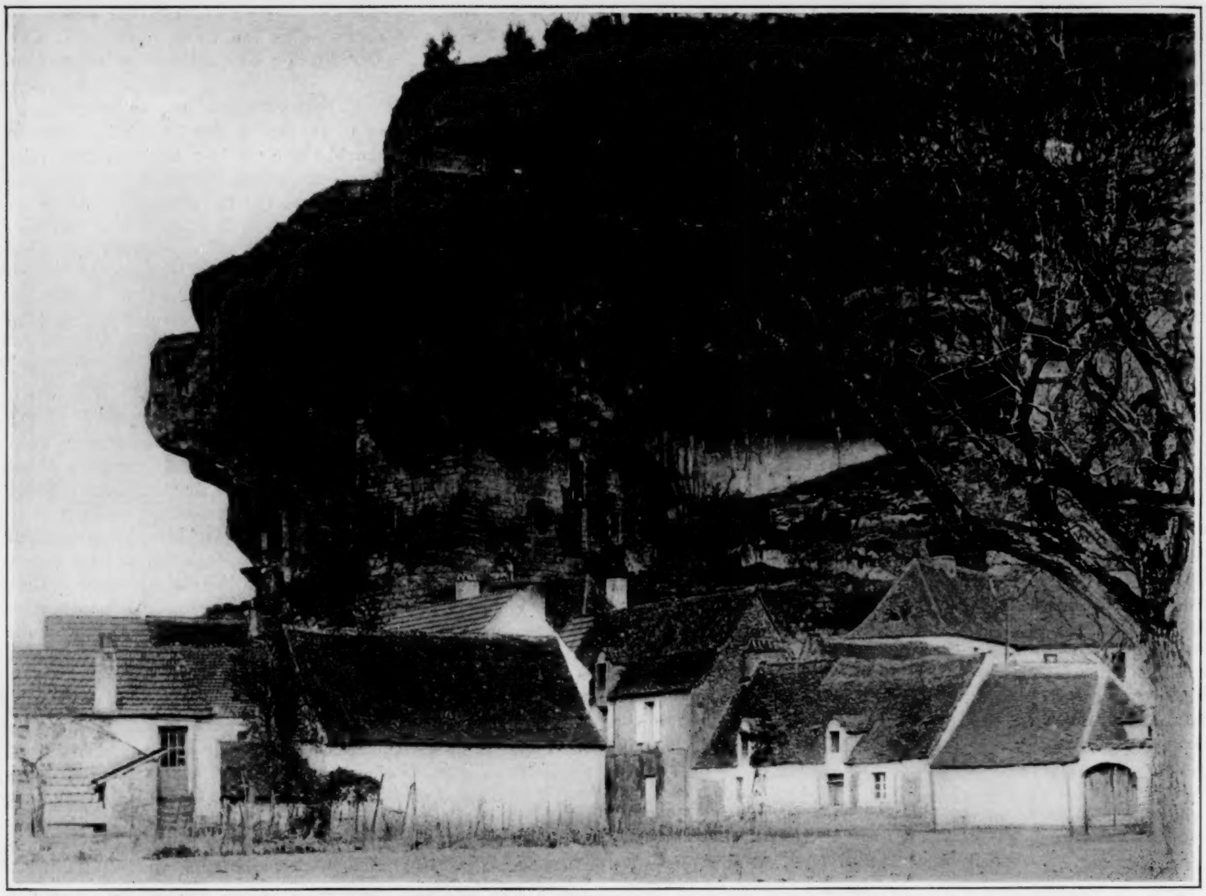
May we not hope that the significance of the geographer's service to business and to the state may be similarly recognized with us? Why should there not be a national university of research at Washington where the varied problems touching the interests of business and the Government could be attacked by the promising young men and women of our universities who could be subsidized in their research and have their reports adequately printed? Only in such a fashion can the nation realize the benefits of service which the geographer, properly trained, and properly supported, is in a position to give.

TURNING A LIABILITY INTO AN ASSET

ONE of the most beautiful and graceful flowers in the southern part of the United States is the Water Hyacinth, whose glossy green leaves and delicate blue blossoms cover many acres of the waters of the St. John River and other streams in Florida. Unfortunately, the plant is so hardy and grows so rapidly that it has spread to an extent which has seriously menaced the navigability of the waterways where it is found. A few years ago it was more or less seriously proposed to stock the rivers where it abounds with hippopotami imported from Europe the argument being made that thus the succulent stems and leaves of this prolific plant might be turned into the nutritious meat of an animal whose flesh is said closely to resemble pork.

A more practicable solution of the problem of turning this pest into an asset has been dicovered in Cambodia, where it made its appearance about 1906, making its way into the rocks and the rivers from Cochin-China, where it seems to have been imported from tropical America about the beginning of the present century. By 1909 the plant had become such a nuisance that the attention of the authorities was called to it. Under the favorable conditions of the Cambodian climate a single plant is said to require only a few months to cover an area of six hundred square meters. In spite of the grace and elegance of its aspect the stalks are so sturdy that one may pass dry-shod over the water where they grow, merely by throwing a board across the leafy carpet they form. This strength is due to the stout fibers of which they are composed. It is these fibers which are now being employed to make an excellent quality of rope, cord, baggings, etc. This has been made possible by a defibrating machine invented by a French resident of Cambodia, named Perrot. The stalks are stripped of their leaves and pass through this machine, which removes all pulpy matter, leaving long, strong and flexible fibers from which it is easy to weave strong and supple cloth, which has been found very useful in taking the place of jute for the making of the paddy sacks which are so important in Indo-China trade. The luc-bingh as the natives call the water hyacinth being an aquatic plant is, of course, highly absorbent of moisture. This disadvantage has been overcome by the inventor by soaking the fibers in a bath of chrome alum, which closes the pores and makes it water proof without injuring its capacity for taking up dyes of all colors. It is proposed to pack the fibers into bales like cotton and export them to France, where it is believed they will find a great variety of industrial applications.

So promising a method of transforming a liability into an asset ought not to be overlooked in this country. The collection of the raw material has been rendered particularly feasible of late by the devising of an apparatus for rapidly and cheaply ridding streams of this and other water plants. This consists in a long saw blade having spindle shaped weights at each end; this is stretched across a stream to be cleared, being supported by men in boats. As the men row down the stream the space between them is quickly and effectively cleared of all water growths.



VIEW OF LES EYZIES, AN UNDERGROUND VILLAGE IN THE DEPARTMENT OF DORDOGNE, FRANCE

Twentieth-Century Troglodytes

Curious Cave Cities Built in the Cliffs of the Chalk Belt of France

THERE is something peculiarly fascinating to small boys, at any rate, and even to a good many adults in the idea of life in a cave. Perhaps this is because of some lurking atavistic instinct in the souls of most of us. While our primeval ancestors were probably arboreal in their habits, like their kindred, the monkey folk, they had not advanced far in their upward climb before they appreciated the advantages to be secured by cave life—advantages of shelter from wind, rain, and storm, from wild beasts, and from the more dreadful hands of their human enemies. Very comfortable it must have been to one of our hard beset early progenitors to take refuge within the very bosom of the kindly earth herself and roll up a convenient boulder by way of locking the front door.

This deep-lying interest which mankind has in stories of caves and cave-dwellers is testified to, indeed, in modern and ancient literature in all tongues. The very word cave brings thronging memories of romance of buried treasure, of fights with fierce animals, of welcome refuge after desperate flight. Pictures at once rise in the mind's eye of that cave of Abdullah which sheltered David, of Robert Bruce's cave with its spider-woven curtain, of the cave of the forty thieves, and so on *ad infinitum.*

Cave dwellers, or troglodites, are mentioned both in Pliny and Herodotus, who give a mixture of real and imaginary facts about them. But few people know, perhaps, that a great many persons still make their homes in the convenient caverns found in the chalk belt in France. This chalk belt, indeed, may be traced not only across France but from the north of Ireland to the Crimea, more than 11,000 miles, and from the south of Sweden to Bordeaux, a distance of 840 miles. No less an authority than Baring Gould declares that the real Garden of Eden was indisputably in the chalk lands; here, man found shelter within the walls of cretaceous rock or under its ledges of overhanging beds and also obtained convenient pieces of flint from which to shape his tools as well as nodules of pyrites from which to kindle a fire in the somewhat chilly interior of his home.

Many books have been written about the early cave men and the vestiges which remain of his tools, utensils, and even the crude but clever art with which he adorned the walls of his home. One of the most famous localities where such traces of primitive cave life remain, is in the Department of Dordogne, in the valley of the Vézère, especially at Les Eyzies, and it is in this region that some of the caves are still inhabited as our pictures show. Another region of the same nature is that of the small river, *Le Loir,* which crosses the fertile upland plain of Beauce and empties into *La Loire,* a much better known stream. Here the river Le Loir has cut for itself a deep furrow in the chalk tufa and the hospitable

cliffs on each side are said to "offer a home to any vagrant who cares to scratch for himself a hole in the friable face" thereof. Here we have the underground city of Trôo, which was originally all underground but is now half in and half out of the earth.

To quote again from Baring Gould: "But what makes Trôo especially interesting is that the whole height is like a sponge, perforated with passages giving access to halls, some of which are circular, and into store-chambers; and most of the houses are wholly or in part underground. The caves that are inhabited are staged one above the other, some reached by stairs that are little better than ladders, and the subterranean passages leading from them form a labyrinth within the bowels of the hill, and run in superposed stories. In one that I entered was an oven, with a well at its side. A little farther in, a large hall, a circular hole in the floor, unfenced, gave access by rope or ladder to a lower range of galleries. Any one exploring by the feeble light of a single candle, without a guide, might be precipitated down this abyss without knowing that there was a gaping opening before him. A long ascending passage, with niches in the sides for lamps, leads to where the fibers of the roots of the trees on the mound above have penetrated and are hanging down. . . .

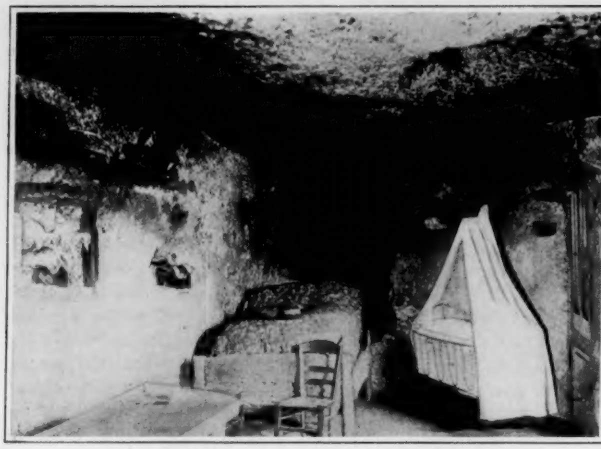
"The town—it was a town once, but now contains 783 inhabitants only—is partly built at the foot of the bluff, but very few houses are without excavated chambers, store-places or stables. The café looks ordinary enough, but enter, and you find yourself in a dungeon. There is but one street—La Grande Rue—and that has space and landscape on one side, and houses built against and into the rock on the other. A notice at the entrance to the street warns that no heavy traffic, not much above the weight of a perambulator, is permitted to pass along it, for the roadway runs over the tops of houses. A wagon might crash through into the chamber of a bedridden beldame, and a motor be precipitated downwards to salt the soup of a wife stirring it for her husband's supper. At Trôo chimneys bristle everywhere, making the hill resemble a pincushion or a piece of larded veal. There in the depth of the hill are wells and to these mothers fearlessly despatch their children to fill a pitcher as often as not without a light.

"Many of the cave-dwellers have but a ledge a few feet wide, and perhaps only a dozen or twenty feet long before their doors, and at the extreme edge one may see the children standing unaffected with giddiness, like a row of swallows, contemplating the visitor. I cannot say how it may be with the lower houses, but those high up are pronouncedly odoriferous; for the inhabitants have no means of disposing of their garbage save by exposing it on their little shelves to be dried up by the sun, or washed down by the rain over the windows and doors of their neighbors beneath.

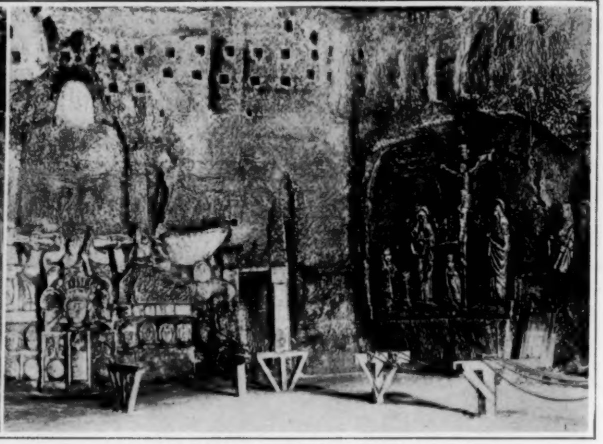
"I wonder how a sanitary officer would tackle the problem of sweetening Trôo. If he attempted to envelop it in a cobweb of socketed drainpipes he would get into a tangle with the chimneys; to carry them underground would not be feasible, as he would have to run them through kitchens, bedrooms and salles-à-manger. But even did he make this cobweb, he could not flush his pipes, as the water is at the bottom of the hill. The ancient Gauls and Britons had a practical and ingenious method of disposing of their refuse. They dug shafts in the chalk, shaped like bottles, and all the rubbish they desired to get rid of was consigned to these, till they were full, when they planted a tree on the top and opened another. Great numbers of these *puticuli* have been found in France. They have been like wise unearthed on the chalk downs of England. They were used as well for the graves of slaves. Now the good citizens of Trôo cannot employ the pitfalls in their caves for this purpose, or the wells would be contaminated. As it is, those wells are supplied from the rain-water falling on the hill of Trôo and filtering down, ingeniously avoiding the passages and halls. There are, however, some dripping caverns incrusted with stalagmitic deposits. But conceive of the

STREET SCENE IN THE VILLAGE OF CHISSAY

FRONT YARD OF A CAVE DWELLING IN THE SOISSONAIS



A BEDROOM IN THE VILLAGE OF BOURRE



UNDERGROUND CHAPEL AT CHISSAY

sponge of Trôo acting as a filter through two thousand years and never renovated. Not the most impressive teetotal orator would make me a water drinker were I a citizen of Trôo."

Apparently things have improved somewhat since the very pessimistic account given above was written. At any rate a more recent writer says that many of these houses are very comfortable, being well aired by an opening in the front and by the large chimneys which extend above ground. Sometimes they are two or three stories high and are provided with ceilings and floors. We are told, too, that upon entering one of the dwellings one is struck by the cleanliness which prevails within; while he is silent as to methods of sanitation employed, he certainly gives the inhabitants credit for the virtue which is next to godliness, and it would seem that people who have learned to keep their houses clean must likewise have devised some practical form of sanitation. Our pictures come from this very region, the most important villages of which are Bourre and Chissay (Indre et Loire) and Brantome and Eyzies (Dordogne).

In the Department of Maine et Loire sometimes whole villages are underground. A curious reason is given for this. Sometimes there is very valuable vineyard land which has to be walled in and used intensively in every part. The owner, therefore, digs a quarry in the surface, thus forming a sort of pit or cellar which is accessible on one side, while the stone taken out is used for fencing in the ground. Then for his own dwelling the thrifty proprietor cuts rooms in the living rock, under his vineyard. These chambers have windows and a door opening into the quarry hole; next a chimney is made by means of a vertical shaft, at whose top a square block of masonry is built and from which the smoke issues. Consequently it has been amusingly said that a village to the casual eye appears to be merely a lot of chimney pots standing on the ground among the vines, its inhabitants being as snugly encased underneath as so many rabbits in a warren.

Along the banks of the Loire from Tours to Saumur there are a great many cave dwellings still occupied. These are very interestingly described by Bell in his "Wayside Pictures" where he says of those at Saumur: "Close to the town are residences, literally sculptured in the face of the naked rock. They are cut in the stone, which is the tufa, or soft gravel stone, and easily admits of any workmanship demanded by taste or necessity. There is no little care displayed in the formation of these strange habitations, some of which have scraps of gardens or miniature terraces before them; hanging from the doorways are green creeping things, with other graceful adjuncts, which help to give a touch of beauty to their aspect. In some cases where the shelving of the rock will admit of it, there are chimneys in nearly all windows; and it not unfrequently happens, especially higher up the road near Tour, where art has condescended to embellish the façades still more elaborately, that these house caves present an appearance of elegance which is almost impossible to reconcile with the absolute penury of their inhabitants. The interiors, too, although generally speaking naked enough are sometimes tolerably well furnished, having an air of comfort in them which, certainly, no one could dream of discovering in such places.

"These habitations are, of course, held only by the poor and outcast, yet, in spite of circumstances, they live merrily from hand to mouth however they can, and by means, perhaps, not always of the most legitimate description. I have a strong suspicion that the denizens of these rocks are not a whit better than they should be; that their intimate neighborhood is not the safest promenade after dark; and that, being regarded and treated as pariahs, they are born and baptized in the resentments which are contingent upon such a condition of existence. You might as well attempt to chase an eagle to his eyrie among the clouds as to make your way to some of these perilous chambers, which are cut in the blank face of the rock, and can be reached only by a sinuous track which requires the fibers of a goat to clamber. There are often long lines of these sculptured houses piled in successive tiers above each other; sometimes with a view to architectural regularity, but in almost all cases they are equally hazardous to the unpractised foot of a stranger.

"Stroll down the spacious quay of Saumur in the dusk of the evening, when the flickering tapers of the temperate town are going out one by one. Roars of merriment greet you as you approach the cavernous city of the suburb. There the entertainments of the inhabitants are only about to begin. You see moving lights in the distance twinkling along the gray surface of the rock, and flitting among the trees that lie between its base and the margin of the river. Some bacchanalian orgie is going forward."

In a book published in 1882 dealing with the history of the Gauls under Vercingetorix a singular statement is made to the effect that in this cave country the old Celtic religion still exists, just as it was practiced before the Roman invasion, but with the single and important exception of human sacrifice. The members of this cult are known as *Les Blancs*, because they cover their heads with a white hood while taking part in the ceremonies, and the priests are clad like Druids in long white robes. They have four meetings in the year, usually in the heart of the forest about an old oak, but the most solemn of all is held near the town of La Clayette. At La Rochebrune is shown a curious two-chambered cave dwelling having eight large holes cut in the floor of the upper chamber. Six of these holes were meant for the convenience of reaching down with a sword or knife and stabbing invaders beneath, while two were intended to provide for the escape of the inmates.

Refractory Substances*

Problems Presented by Natural and Artificial Products Possessed of High Resistance

By A. Bigot

Doctor of Sciences and Ceramist

THE word refractory is rather vague. It is applied to ceramic substances which fuse at a high temperature, but the temperature limits are not indicated in the designation "refractory."

In principle the more refractory a ceramic substance the higher its temperature of fusion; but besides the fusion point there are a number of other properties involved which vary according to the nature of the refractory substance.

All of these products become softened at a temperature lower than that of their fusion point, and in fact, in the majority of cases the fusion is purely and simply a softening and there is consequently no precisely determined temperature which can be regarded either as the point of fusion or as the point of softening.

The resistance to crushing exhibited by ceramic products varies according to the degree of temperature and the pressure to which they are subjected. It is not alike for the different refractory substances. The same thing is true as regards resistance to wear and tear, to cold, and to heat, all of which vary considerably.

The resistance of refractory substances to scoriæ and to various chemical agents in fusion is likewise very variable according to the nature of the substances themselves and to that of the fused substances in contact with them.

Our knowledge with respect to the specific heat, the electric and calorific conductibility, and the radiating power of refractory substances at various temperatures is still very imperfect.

Finally, a certain number of them undergo a change of volume when subjected to high temperatures in industrial furnaces.

The question of refractory materials is, therefore, highly complex.

The requirements of metallurgy have led in the last few years to a marked increase in the manufacture of refractory products. The action exerted by the chemical reagents which are formed in furnaces has necessitated the manufacture of different refractory materials.

We have little information as to the processes employed by the ancients in the making of such products. We know that Chinese porcelain, whose manufacture goes back to about two centuries before the Christian era, was fired in refractory containers of clay. A work upon the manufacture of glass in the 17th century speaks of the almost exclusive use of the clay of forges in Normandy for the manufacture of pots in the glassworks in France.

In the course of the last century Sainte Claire Deville and Le Chatelier pointed out the refractory properties of white bauxite.

The industry of making bricks of magnesia and chrome iron has been founded and that of the manufacture of graphite crucibles has been developed.

When we take these products in the form in which they come from the factory and subject them to high temperature some of them diminish in volume, others increase in volume, and others still retain approximately the same volume.

The clays and the bauxites diminish in volume when their temperature is raised and also when refired a number of times at the same temperature.

Magnesia bricks behave in the same manner; thus magnesia bricks fired at 1,500°C. undergo from 5 to 10 per cent of contraction when raised to 1,700°C. When bricks which diminish in volume at a high temperature are so placed inside of furnaces that one of their surfaces receives a higher temperature than the other, the hotter side contracts and the material splits on that side.

Graphite crucibles, which are composed of a mixture of graphite and of refractory clay likewise undergo a high degree of contraction when used in fusion furnaces. The products of silica, on the contrary, with some very rare exceptions, undergo an increase in volume of greater or less amount according to the nature of the elements of which they are composed and the temperatures to which they are subjected; thus silica bricks, previously fired at 1,400°C. frequently undergo an elongation of 4 or 5 per cent when raised to the temperature of 1,700°C., which is that of the Martin furnace. In this case the part of the bricks in contact with the gases of combustion swell, split, and become friable.

Refractory substances having chrome iron as their base, when properly compressed, undergo an insignificant degree of contraction up to the temperature of 1,500°C. and may, therefore, be considered as refractory materials having a fixed volume.

In accordance with the above description refractory products may be divided into two classes:

1. Those having a variable volume;
2. Those having a fixed volume.

The great majority of refractory products being manufactured at present are comprised in the first class: but in many cases their diminution in volume in industrial furnaces has proved to have so many disadvantages that gradually their use has been discontinued in furnaces of high temperature and they have been replaced by refractory materials having a fixed volume.

Moreover, it is possible to reduce the clays, the bauxites, the magnesias, and the silicas to a fixed volume before making use of them; for this purpose it is only necessary to heat them previously to such a temperature as will cause them to undergo their maximum degree of contraction or of elongation.

REFRACTORY PRODUCTS HAVING A CONSTANT VOLUME

Refractory products having a constant volume are manufactured either with the minerals found in nature, or else with minerals which have been subjected to some previous process of treatment. They may be divided into two classes:

1. Refractory products having natural minerals as their base;
2. Refractory products having artificial minerals as their base.

REFRACTORY PRODUCTS HAVING NATURAL MINERALS AS THEIR BASE

The minerals capable of being employed for the manufacture of these products may be divided into three classes:

a. The spinels of which chrome iron is the principal;
b. The corindons or corundums;
c. Zircon.

a. Chrome Irons.—The chrome irons employed in this manufacture are found in different parts of the globe, principally in New Caledonia, Canada, Siberia, Greece, etc. In order for products having chrome iron as their base to be of good quality it is necessary that the raw materials should contain about 50 per cent of the oxide of chromium in the state of chrome iron, $FeOCr_2O_3$. The mineral is first crushed and then strongly compressed with a small amount of binder and fired at a temperature of about 1,500°C. After this firing when the material is subjected to a temperature of

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1,700°C. the amount of contraction is practically insignificant.

The other spinels are either too rare to be employed, as in the case of the aluminate of magnesia, or else they are not sufficiently refractory as is the case with titanate of iron.

Refractory materials having chrome iron as their base have a comparatively limited range of employment. Their principal application is in Martin furnaces to separate the products of magnesia from those of silica, with which they do not combine. Chrome iron is an excellent refractory material and is attacked with difficulty by slag. Thus far the ores from New Caledonia have been found to be those having the highest content of chromium.

b. Natural Corundums.—The natural corundums consist of alumina with a comparatively small quantity of silica. Good natural corundums contain from 95 to 98 per cent of alumina. The principal deposits capable of being exploited are found in Madagascar, in the Indies, and in the southern part of Africa. The refractory quality of these ores depends chiefly upon the content of alumina and the almost entire absence of any impurity except the silica.

A highly refractory variety of corundum is found in Madagascar in considerable masses. Its quality is superior to that of all other known corundums, but thus far its exploitation is scarcely more than projected. During the war a few hundred tons of these corundums were employed to manufacture ceramic mill stones, but their application to the manufacture of refractory bricks has not yet begun, the chief reason being the difficulty of transportation both within the island and from Madagascar to France.

Agglomerates of corundum after being compressed must be heated to 1,400°C. Products thus obtained will not undergo contraction either during firing or when heated to a temperature higher than 1,700°C. Their fusion point is a little bit lower than 2,000°C. Recent experiments made with corundum bricks in Martin furnaces show that they are readily attacked by the lime of the slag, forming aluminates of lime and fusible silico-aluminates of lime.

c. Zircon[1].—Zircon has recently been discovered in Madagascar in considerable masses. It is found in the form of crystals, those often exceeding 1 kilogram in weight. It consists of approximately pure silicate of zirconium, SiO_2ZrO_2, containing 33 per cent of silica, 66 per cent of zircon, and about 1 per cent of impurities. It fuses at a temperature higher than 2,000°C.

In order to manufacture refractory products with zircon the crystals are first carefully washed in order to remove foreign matter adhering to them. They are then crushed and mixed with three or four per cent of slacked lime or with five to eight per cent of kaolin. The mixture is compressed and fired at a temperature of about 1,500°C.

The pieces thus obtained undergo no perceptible contraction during the firing and can be heated to 1,750°C. and even higher without change of volume. Their fusion point is a little above 2,000°C.

These agglomerates of zircon exhibit the property of being almost incapable of attack by melted glass, by slag, etc. The presence of lime and of iron oxide in the compounds of zircon have but slight influence upon their fusion point; thus a mixture consisting of 83 parts of zircon, 5 parts of lime and 12 parts of iron oxide fuses at a temperature of 1,830°C. The flux of zircon is mainly alumina. If we mix together equal weights of kaolin, which melts at 1,800°C., and of zircon which melts at a temperature higher than 2,000°C., the mixture melts at 1,450°C.

This fusibility of the mixture of zirconium, oxide of silica, and alumina is also found with the oxide of glucinium in the presence of silica and of alumina. Thus the emerald, which is a silicate of alumina and of glucinium fuses at 1,470°C., whereas the oxide of glucinium is difficult to fuse even at 2,300°C. This is obviously the fittest mineral for use at high temperatures; in furnaces, electric furnaces, the crucibles of glass works, for the fusion of quartz, etc. It possesses the same properties as zircona, which will be described further on, but its manufacture is marked by a tremendous advantage over that of the latter, i.e., it can be made by the ordinary process without the intervention of the long and burdensome chemical treatments required for zircona.

[1]Products having zircon as their bases have been patented.

Granular zircona compressed with a suitable agglomerate, and fired at about 1,500°C., forms an abrasive material of the first order. The discovery of deposits of zircon is still too recent for any manufacturer to have undertaken the preparation of this product, but the experiments which have been made with respect to it are absolutely definite and convincing, and it is certain beyond a doubt that refractory materials having zircon as their base will shortly undergo a higher development, because of the high refractory power of this mineral, as well as because of its great resistance to chemical action.

REFRACTORY SUBSTANCES HAVING ARTIFICIAL MINERALS AS THEIR BASE

Among the list of artificial minerals here considered there must be included not only synthetic minerals but also those which have been subjected to physical or chemical treatment of some sort before being employed for the manufacture of refractory materials. These minerals, which are pretty numerous, should all be subjected to a very high temperature before being employed.

a. Products of Silica.—These come under the head of refractory materials of variable volume; however when these substances have been fired at the time of manufacture, under circumstances such that they have fully attained their increase in volume, they may be regarded as belonging in the class of refractory material having a constant volume.

During the process of manufacture the rocks employed should remain in grains in the mass. At the present writing there are hardly more than two factories in the entire world which supply silica products of this sort.

b. Zircona.—Considerable amounts of zircona, ZrO_2, are found in Brazil; unfortunately, however, it contains a rather large number of other minerals, such as silica, oxide of iron, alumina, oxide of titanium, oxide of manganese, etc., which very considerably lower the softening temperature and the fusion temperature. The zirconas of Brazil contain from 80 to 85 per cent of ZrO_2. Certain rocks, which are however quite rare, contain from 92 to 95 per cent of zirconium oxide.

In order to purify natural zircona is must first be crushed into an impalpable powder, and then attacked by hydrochloric acid, which dissolves the oxides of iron and manganese if it is desired to pursue the purification and to remove the silica, the alumina and the oxide of titanium; the pulverized zircona must undergo long and tedious processes of treatment in order that a zircona containing 98 to 99 per cent of ZrO_2 may be finally obtained. When this treatment has been completed the zircona obtained must be calcined at a very high temperature, preferably in an electric furnace before being agglomerated. The calcined zircona is then agglomerated with a small amount of a suitable binder, either organic or inorganic in origin; it is then subjected to a high degree of compression and fired at a temperature of from 1,600°C. to 1,700°C.

The materials thus obtained will resist a temperature of over 2,000°C. and have acquired the characteristic property of being capable of being repeatedly heated and cooled, of possessing a very slight coefficient of expansion, and of being almost incapable of attack by fused scorial glass and oxides.

The refractory qualities of zircona have already led to its use in the manufacture of crucibles, tubes, small portions of various apparatus or machinery, etc. These applications, already numerous, will doubtless be extended in direct proportion as the processes of purification become less difficult and less costly.

The other artificial minerals used to prepare refractory ma-

terials having a fixed volume are obtained either by means of the electric furnace or by treatment in a cupola.

Among those obtained by the electric furnace we may mention:

c. *Carborundum.*—Carborundum is the carbide of silicon, C Si. After being properly agglomerated and compressed it is fired at a temperature of about 1,300°C. Refractory materials having carborundum as their base possess the properties of being good conductors of heat, of being almost entirely non-sensitive to changes of temperature, and of being extremely difficult to break. Articles made of such material can be brought to a red heat and then cooled an indefinite number of times. As a result of these qualities these products find a great variety of applications. But carborundum begins to decompose at a temperature of 1,500°C., becoming covered with a vitreous coating which gradually increases in thickness. Hence 1,500°C. is the maximum temperature at which this material can be employed.

d. *Fused Quartz.*—The electric furnace is employed to prepare fused quartz. It has a wide variety of applications, tubes, muffles, containers, etc. But those used in refractory industries have a defect peculiar to quartz as at present manufactured, namely, that when long maintained at a high temperature it spontaneously crumbles into powder. It is quite certain, however, that a remedy will shortly be found for this defect, since experiments along this line have already met with very satisfactory results. It must be remembered also that this industry is very recent and that the electric fusing of quartz presents many difficulties. Furthermore, since quartz fuses at about 1,750°C. there is reason to believe that it will not be long before we shall be able to obtain fused quartz merely by the process of melting it at this temperature in crucibles which are refractory enough and sufficiently immune to attack to contain the matters in the process of fusion.

e. *Artificial Corundums.*—Artificial corundums are obtained by fusing carefully selected bauxites in the electric furnace. When these artificial corundums have been properly prepared and crushed, the compounds of iron which they contain are removed by means of an electric magnet; after this is done there remains a crystalline substance which contains about 95 per cent of alumina. This resembles the natural corundums, and the refractory or abrasive materials which are prepared by means of this artificial corundum are similar to those obtained with natural corundums of good quality.

The cupolas which are suitable to be employed in the manufacture of refractory products having a fixed volume are described in the Lecesne and Gowen patents, as well as the process required in their manufacture.

The fragmentary materials are mixed with from 15 to 20 per cent of their own weight of anthracite of good quality. After being lighted the mixture is subjected to the action of a blower. This causes the temperature to rise to the vicinity of 2,000°C.

The materials become fused in successive layers without, however, becoming completely fluid. At the termination of the operation they are found to form a mass which is separated from the cupola by means of a special device which prevents this block of material from adhering to the refractory walls. It is obvious that this process is exceedingly economical compared with the electric process.

f. *Fused Bauxite.*—The bauxites fused by this process, after crushing and treatment by the magnetic separator, are agglomerated with suitable binders and strongly compressed. The products manufactured with white bauxite to form this agglomerate do not undergo any contraction after being removed from the press up to the temperature of 1,750°C. They constitute refractory materials of the first order, but they are sensitive, like corundum, to the action of fused slag. They are used principally in gas and coke furnaces, rotary cement furnaces, etc.

Since these refractory substances are highly abrasive and undergo no change of volume, they last about five times as long in the rotary kiln as other coverings thus far employed. The manufacture of fused bauxites was begun in France during the war and has given rise to an entirely new industry.

g. *Fused Clays.*—Clays and kaolin are fused by the same sort of process in the cupola. The operation proceeds as with bauxite and the products thus obtained after being properly agglomerated and compressed undergo no further contraction up to a very high temperature.

This operation has not changed either the temperature of fusion of the substances employed or their softening temperature. It has transformed them into substances which are more compact, their density having increased by 20 per cent, while their porousness has diminished by 25 per cent and their resistance to wear and tear is doubled. The manufacture of refractory materials from clays and kaolins has not yet become a practical industry, but it is quite certain that it will shortly commence a legitimate development.

h. *Magnesia.*—After magnesia is subjected to the treatment of the Lecesne cupola it does not undergo fusion if it is sufficiently pure; but it is agglomerated, becoming absolutely compact, and acquires its full degree of contraction. It behaves in this matter like the clays and the bauxites treated in the cupola. The magnesia is thus actually calcined to death because of the high temperature to which it has been subjected and when it is afterwards crushed and agglomerated it yields products which undergo no perceptible contraction up to 1,700°C. These products are much more stable and less brittle than the present products.

The manufacture of magnesia products calcined in this manner has not yet become a current practice; furthermore the experiments made in this line are still too recent, but it is quite certain that before very long the process of the Lecesne cupola will advantageously and economically replace the present process of calcining magnesia to death in rotary furnaces.

The cupola process could likewise be adopted for the fusion of quartz, for the calcination to death of dolomite and the various other minerals and it is certain to play a very important rôle in the industry of refractory products having a fixed volume.

SUMMARY

This brief exposition of the matter shows that the number of refractory products having a fixed volume is quite large, and that up to the present time a very small number of them have been actually exploited. The needs of metallurgy, of electrical furnaces, of kilns, etc., will undoubtedly greatly further the development of the manufacture of these materials.

At the present time with the materials commonly employed the inside walls of an industrial furnace can scarcely be heated to a temperature greater than 1,700°C., that of the Martin furnace. But when industry succeeds in furnishing refractory materials having zircon or zircona as their base, it will be possible to obtain a temperature of 1,900°C. in furnaces and this will doubtless lead to the development of various novel applications.

CHINESE INK

The intensely black inks have various sorts of finely divided carbon as their pigment and the vehicle in most instances is some type of oil or varnish. India ink is the name often applied to what is in reality Chinese ink. The best of this variety comes from the Anhui Province and is made from the lamp black produced when wood oil is slowly burned in one earthenware vessel and the soot or lamp black produced is collected on the sides of a second jar placed above the first. A paste is made with varnish and pork fat and this is then mixed with glue. Some ink is made from the soot of sesame or rapeseed oil, but in any case the paste is pressed into molds. There are of course many grades of this ink; the lower being made from the coarser soot and glue. In 1918, the Chinese exported 127,000 pounds of this ink.

Chemical Action at a Distance

Materials Which Differ in the Number of Electric Charges Carried by Their Ions

By Albert F. Fellows

THE idea that actual mechanical contact is essential to a chemical reaction was overthrown a number of years ago. It will be the purpose of the author to show the experimenter how he may convince himself that chemicals which never touch each other can react.

The first experiment to illustrate this interesting phenomenon is to oxidize ferrous chloride to ferric chloride by chlorine which never comes in contact with it. Ferrous chloride is iron dissolved in hydrochloric acid. The ferrous salt and its water solution are green. The ferric salt is obtained as dark reddish brown crystals or solutions. The outstanding difference of these salts is the iron content. The ferrous chloride contains 28 per cent of elemental iron; whereas the ferric chloride usually has about 20 per cent of iron. There is a far more important difference which we shall find and consider later.

The ferrous chloride, if not at hand, may be prepared by dissolving nails in hydrochloric acid. If the ferrous salt is already at hand, a check up test should be made to determine if there is any ferric salt present. This is unnecessary with the freshly prepared ferrous salt for the nascent hydrogen which is evolved constantly reduces any of the ferric salt which may have formed. In ordinary practice we should pass the chlorine directly into the beaker containing the ferrous chloride to form the ferric salt, but this produces actual contact and we desire to perform this oxidation without mechanical contact of the reacting substances.

Pour the freshly prepared ferrous chloride into a small beaker. In another beaker of the same size prepare a concentrated solution of common salt (sodium chloride). The levels of the solution must be equal. The two beakers are then connected by a bent glass tube filled with a solution of sodium chloride. If desired the ends of the tube may be loosely plugged with filter paper. As we know that chemical reactions, under suitable circumstances, may produce an electric current, we may, conversely, say that the existence of a current is an indication of the occurrence of a chemical reaction. To detect whether any action takes place, connect a galvanometer by means of copper wires to a piece of platinum foil in each beaker. This arrangement is shown in Fig. 1. If there is no flow of current indicated by galvanometer, we conclude that there is no action taking place. Observation shows the galvanometer is not deflected, hence no action.

A chlorine generator is next set up. Ten cubic centimeters of hydrochloric acid are treated with 5 gms. of manganese dioxide. Conduct the evolved chloride into the beaker containing the table salt solution. The ferrous chloride in the other beaker is very slowly oxidized to ferric chlorine by chlorine in an entirely different beaker. The presence of ferric chloride may be proved by testing with potassium sulphocyanide solution.

Whether the beakers are two inches or two feet apart makes no difference, for the object of the glass connecting tube is to complete the circuit. It is absolutely impossible for the chlorine to pass through the tube for, as we shall see later, the chlorine exists in the ionic state. Ions move with very definite velocities which are accurately known. With a tube six inches long, many hours would elapse before the chlorine could appear in the beaker.

How can this mysterious phenomenon be explained? A clue is furnished by the galvanometer, for at the appearance of the first bubble of chlorine, a deflection of the scale is recorded. The galvanometer also shows that the current passes from the table salt solution to the ferrous salt solution. The principles of electro-chemistry show that the chlorine passes into the ionic state; that is, the chlorine takes on an electric charge. Chlorine is a non-metal consequently it acquires a negative charge. The electricity must come from something, we believe that it comes from the electrode. The platinum electrode, immersed in the sodium chloride, loses negative charges of electricity to the chlorine. This electrode, since it has lost negative charges, becomes positively charged and the stream of electric charges, or current, flows over to the beaker containing the ferrous salt.

Iron in ions of ferrous condition carries two charges of electricity represented by: Fe^{++}. Iron in this condition is bivalent. Iron may also carry three charges: Fe^{+++} and is said to be trivalent. We have seen that the current passed from the salt solution to the iron solution. What happens when the current arrives? The bivalent ferrous ions each grab another charge of electricity from the incoming current. Then with three charges an iron ion is surely different from what it was with only two charges; and so it is for it is no longer ferrous chloride but ferric chloride. In this light, the most important difference between ferrous and ferric salts is not color or percentage composition but the number of electric charges.

From this viewpoint, nearly all reactions are to be considered as nothing but changes of electric charges; and all reactions are, in a certain sense, "reactions at a distance" for the reacting substances need not come into actual mechanical contact in order to allow the necessary electric charges to change places. We now see that the idea which at first we thought so unusual is almost universal.

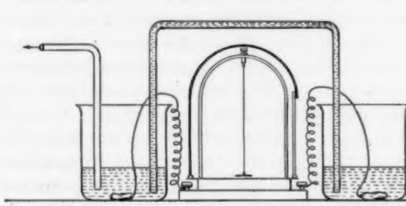


FIG. 1

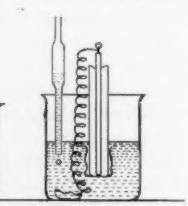


FIG. 2

In the introductory paragraph, the idea was suggested of how abstract phenomena lead us, when solved, to important applications. The whole science of electromotive chemistry is bound up in the foregoing demonstration. It gives us some new electrical cells for producing current electricity and leads us to many theoretical considerations. Chief among these is the concept of valency. For the past three-fourths of a century eminent scientists have endeavored to find out what valence is; yet there are few topics in modern chemistry in which scientists have so disagreed as in this very subject.

It appears that the only scientific way to treat the subject of valence is by Faraday's law which says: "The valence of an ion is a function of the number of electrical charges that it carries." An univalent ion carries one charge, a divalent ion two charges and so on. We now call Sir J. J. Thomson's electron theory to our assistance and identify the electric charges of which we have spoken as our friends the electrons which now are being blamed for so many things. In terms of the electron theory, valency is easily explained. A univalent negative element carries one electron or negative charge of electricity, a divalent element carries two electrons. Since the electron is a particle of negative electricity and opposite to a positive charge, an univalent positive ion has lost one electron, trivalent positive ion, such as ferric iron, has

lost three electrons; and so on up to eight possible electric charges.

An experiment of similar nature to the preceding one uses the same apparatus, but different solutions. In place of ferrous chloride, stannous chloride solution (11 grains in 100 cc's. of water) is used. The sodium chloride has been acidified with a few drops of hydrochloric acid. The beakers are filled with acidulated salt solution. As before the electrodes are connected to the galvanometer. No current is observed to pass till a few crystals of mercuric chloride ($4H_2 Cl_2$) have been placed on the electrode of the beaker containing the salt. Chlorine may be used as before if desired. The current is immediately set up and moves from the beaker containing salt to the beaker containing the stannous chloride. The bivalent tin Sn^{++} by the acquisition of two positive charges becomes the quadravalent stannic tin ion: Sn^{++++}. This arrangement represents the galvanic cell of R. Lupke.

Another demonstration of chemical action at a distance is still more convincing. It is from an entirely different cause, that of solution tension, and is as easily performed as the one based on charges of electric charges. Zinc dissolves in sulphuric acid which never touches it and dissolves far more rapidly than if the acid was in actual contact with the zinc. Pure zinc dissolves very slowly in sulphuric acid. A piece of copper wire is soldered to the zinc and this wire in turn to a piece of platinum foil. The experimenter could use a clean battery zinc screwed to a wire bearing the small platinum electrode. Pass the electrode through a cork supported by a four or five-inch test tube with the bottom broken off and a piece of quite heavy paper substituted. It is much more convenient if the top of the tube is broken off and the heavy paper tied to the top tightly, for the flange affords a better grip for the string. The zinc is then supported in the tube. A larger beaker is filled with a solution of ammonium sulphate, part of this solution is put into the inverted test tube and the test tube is put into the beaker. This is shown in Fig. 2. After a few moments the platinum electrode is immersed in the ammonium sulphate solution. There is not any trace of a chemical action; the zinc or platinum does not dissolve in ammonium sulphate; no bubbles are given off, as would be the case if the zinc was dissolving. By means of a pipette, sulphuric acid is added to the foil in the beaker. Hydrogen is evolved not from the zinc but from the platinum foil, and the zinc dissolves. The platinum we know is not attacked by sulphuric acid but the bubbles of hydrogen that come from the platinum. If we test the ammonium sulphate solution after the action has gone on for some time, the presence of zinc is shown. The best reagent for this purpose is potassium ferrocyanide which throws down a white precipitate in solutions containing zinc. The object of the heavy paper or parchment over the test tube is to keep, at least for a time, the sulphuric acid introduced into the beaker away from the zinc.

To explain this peculiar behavior, we must consider two more important concepts of physical chemistry, solution-tension and osmotic pressure. W. Nernst introduced the concept of solution tension into physical chemistry. He showed that since the metals have the possibility of passing into solution as ions, then every metal in water has a certain solution-tension which varies for the different metals. Therefore, in consequence of this solution-tension some ions are forced into solution. We have seen that atoms become ions by acquiring an electric charge. In this case the charge comes from the bar of metal which then becomes negatively charged. But there is another force, which opposes solution-tension, called osmotic pressure. Osmotic pressure tends to drive the metallic ions out of solution and upon giving their charges, they become atoms of the metal. The metal becomes positively charged. Since we must have an equal number of positive and negative charges to form an equilibrium, it becomes a matter of which is the greater, the solution-tension or the osmotic pressure.

In our special case, we find that the solution-tension of zinc is enormous. It is greater than the osmotic pressure of its metal ion in any of its solutions. But in order that the zinc may dissolve it is necessary for the hydrogen cations of sulphuric acid, H^{++} to give up their charges and escape. If the metal as zinc, has a high solution-tension, the hydrogen ions cannot get to it, and if the hydrogen cannot get to the zinc, how can it give up its charges and become hydrogen gas which of course escapes? But platinum has a low solution-tension. It is so small that it cannot be detected by ordinary methods. The hydrogen ions from the acid give up their charges to the platinum and escape as hydrogen gas. These are the bubbles which one observes being driven from the platinum foil. The charge is conducted along the platinum to the copper wire to the zinc. The zinc atoms, having more charges, are able to overcome the resistance of the osmotic pressure and pass into solution as ions pairing themselves with the sulphate ions, SO_4^{--}, which were originally combined with the hydrogen ions, H^{++}, to form sulphuric acid. This is possible, for the hydrogen has disappeared after losing its ionic state. With this explanation the amateur will see that the sulphuric acid does not pass through the paper into the tube to attack the zinc, as he perhaps suspected. The best way to settle such a doubt is to try the litmus test. If the experiment has been carefully performed, the solution will be perfectly neutral.

THE ELECTRIC ARC IN ANALYSIS

At the Boston meeting of the American Electro-Chemical Society, April 8th to 10th, Mr. William R. Mott of the research department of the National Carbon Company, Cleveland, gave an interesting outline of his method of qualitative analysis by means of the electric arc. The chemist is familiar with the flame tests in use for so many years where the spectroscope is used to detect lines in the flame resulting when the sample under analysis is heated on a platinum wire. He is also familiar with methods involving the production of beads with borax in the flame, and of either oxidizing or reducing samples under the blowpipe on charcoal. Mr. Mott's method may be considered an extension of this type of testing and involves apparatus less complex than the spectroscope.

The apparatus used is a carbon arc lamp enclosed in a way to project an image upon a screen with a magnification of 20 diameters. In one of the solid carbons a cup-like cavity 10 mm. in depth and diameter is hollowed out, the carbon being the lower one of the pair and the positive pole. A half gram of the sample is used and the electromotive force is 25 amperes at 50 volts from a 110-volt line.

Mr. Mott has already developed good tests for about 65 elements which can be identified with ease, whether in their ores, oxy-compounds or alloys. The phenomena noted include the nature and color of the material deposited on the pole as the result of distillation, the smoke, sparks and flame tip color obtained, and the odor of the fumes evolved. Many peculiar characteristics have been noted, thus the emission of smoke from the hot upper carbon on breaking the arc has been found to be a delicate test for molybdenum, the phenomenon not being produced by any other element. Calcium produces an unmistakable red, and arsenic, iodine and tungsten have characteristic odors.

Impurities are often discoverable with the procedure of distillation of the sample and Mr. Mott states that on the average nine-tenths of the components in unknown mixtures of any 10 of the 65 elements for which he has worked out means of identification can be named. Fortunately, many of the elements which are difficult to determine by the usual methods are easily identified by this new method.

The method has not been employed by a sufficient number of workers safely to predict its future, but it certainly has wonderful possibilities in the hands of a trained worker and should fit into the list of methods by which the chemist attacks his problem to a degree at least as great as micro-chemical methods which have proved their utility.

The Breaking Up of Nitrogen*

Theory of the Transmutation of Metals Startlingly Verified by Rutherford's Experiments

By Dr. E. Regner

[In the SCIENTIFIC AMERICAN *for Dec. 6, 1919, we published a note entitled "Is Nitrogen an Element" dealing with Rutherford's experiments in the breaking up of nitrogen. We are now able to give a more extended account of these fruitful investigations.*—EDITOR.]

THE extraordinarily active development which occurred in the science of physics during the nineties, and which has essentially altered in various points physical concepts of the universe, seems even yet to have lost nothing in intensity. While the war undoubtedly interfered with experimental research, on the other hand the hypotheses of various investigators are beginning to construct the theory of a whole new world, namely, the world of the atom.

That the atom must possess an internal structure has long been hinted at through the theory of the periodic system of the elements, from the fact that in studying the series of the elements we find that nearly all their properties alter in a *periodic* manner in accordance with their atomic weight. The complexity of the spectra which are emitted by the separate elements proves further that the internal structure of the atom must certainly be composed of some sort of basic parts. All atoms send out when they shine rays of great multiplicity of wave lengths which indicates that vibrations of very different kinds take place in the atom and that, consequently, the atom cannot be a single unit, but must consist of many parts each of which is capable of having a special vibration. The discovery of radio activity has taught us also that the heaviest atoms (namely those of the radio active bodies) more or less rapidly decompose in which process they usually project from themselves a ray of helium atom (alpha particle). Thus we know that the helium atom is a common constituent of radio active bodies and it is presumable that they also contain other atoms. Since the beta rays which issue from radio active atoms are electrons (negative atoms of electricity) these also must form another element of the atom. At the same time we are obliged to believe that the cement, so to speak, which holds the different parts of the atom together consists of the electric force which operates between the negatively charged electrons and the remaining constituents of the atom; and the latter constituently must be positively charged since otherwise the atom would fly apart.

By Rutherford starting from the phenomena of radioactivity and by Bohr who based his theory upon the regularity and conformity to law exhibited in the spectra of the elements, a so-called atom model was constructed which conforms to so many facts in various realms of physics that in all probability it may be considered as representing not merely a model, i.e., a mechanical representation but an actual description of the structure of the atom. According to this model all atoms are built around extremely minute nuclei which are positively charged, and the strength of whose charge increases in proportion with the weight of the atom. The smallest charge is possessed by the hydrogen nucleus, namely, a charge which is exactly as great as that of the electron itself but of an opposite (positive) sign, consequently, the hydrogen nucleus can be conceived of as the positive elementary quantum (atom of electricity). Helium with the atomic weight of 4 has a nucleus with twice as great a charge; carbon with the atomic weight of 12 has the nucleus charge of 6 and sulphur whose atomic weight is 32 that of 16. Hence we see that in elements with a lower atomic weight, the nucleus charge is equal to half the atomic weight; while in the heavier atoms the nucleus charge is lower, so that uranium with the atomic weight of 238 has a nucleus charge of only 92 positive elementary charges. The nucleus charge is decisive for the structure of the atom and determines the atomic weight and the position of the atom in the periodic system. The number of the elementary charges possessed by the nucleus of an atom is, therefore, also called its order number. The negative electrons rotate about the positive nucleus and in each atom do so in a number which is equal to that of its nucleus charge or order number; for, externally, the atom itself must appear to be electrically neutral. In the case of the hydrogen atom, therefore, only one electron rotates about the nucleus, while in helium there are two electrons in rotation, in sulphur 16, and in uranium 92.

The diameter of the path pursued by the electrons is regarded as the diameter of the atom, consequently, in the case of hydrogen, a magnitude equal to 0.1 millimicrons (1 millimicron equals one millionth part of the millimeter). In the case of a larger number of electrons radiating about the nucleus they are represented as rotating in groups arranged in the form of rings and at diffrent distances from the nucleus.

The processes which occur in these rings of electrons need not here concern us.[1] We need only refer to the brilliant success obtained by Bohr's hypothesis that the electrons follow definite paths governed by the so-called quantum of effectiveness (efficiency quantum) of Planck. By means of this hypothesis he succeeded in calculating the wave length of a ray of light proceeding from an atom, and in this manner of explaining the *structure of spectra.* We may also mention that the exact determination of the ray having the highest wave which it is possible for an atom to emit, namely, that of the X-ray has led to the discovery of an extraordinarily remarkable law governing the wave lengths of these rays and the nucleus charge or number of the atom. With the help of this relationship which was discovered by Moseley, it is now possible to calculate with certainty the location of all the elements. A domain of extraordinary extent is thus open to research; but it is now necessary to discover the arrangement of the electrons in the rings in order to understand the periodic repetition of certain definite chemical and physical properties in accordance with an increase in the atomic weight. While thus far we have succeeded only in formulating somewhat probable theories as to the structure of the electron rings at least the path which we must follow lies pretty clearly before us. It is also possible that our knowledge concerning the electron rings may be considerably extended through experiments indicated by this theory, for the alteration we are able to observe depends upon the constitution of the rings. Thus we can in many different ways put an atom in a condition of so-called excitation which is first marked by the fact that the paths pursued by the electrons are suddenly enlarged spasmodically; when the electrons return to their normal paths certain spectral lines are emitted and these lines can now be calculated by means of Bohr's law: it is also true that an atom can undergo an entire loss of an electron, e.g., the hydrogen atom can lose the only electron that revolves about its nucleus. In this case there remains the positively charged hydrogen nucleus and it is this which has long been known as the positively charged hydrogen ion. Hence a hydrogen atom loses its rings when "ionized."

*Translated for the *Scientific American Monthly* from *Die Umschau*, Frankfurt-am-Main, May 1, 1920.

[1] An easily comprehensible account of the "atomic theory in its latest development" (in German) has been written by L. Graetz (Stuttgart), 1918. Readers without special technical knowledge will find that the admirable volume by A. Sommerfeld upon "Atomic Structure and Spectral Lines" (in German), published by Vieweg in 1919 will form an excellent introduction to the preceding work.

Very different are the conditions in the case of the nuclei of atoms; indeed, the position of the element in the periodic system, i.e., its individuality as a definite atom depends upon the nucleus, its charge and its form. This individuality is non-alterable as we know. We can heat, fuse, and evaporate or dissolve atoms of gold, and while they change their aspect in a certain measure, their individual character remains the same. The forces which proceed from the electron rings come into action here; the rings may be altered during these processes but the *nucleus* of the atom remains always the same.

Consequently we must regard the *nucleus of the atom* as a structure of extraordinary stability which thus far we have not been able to alter with the forces at our disposal in the laboratory. We are unable to change any atom into another and as we know the cause of this resides in the stability of the atom nucleus. We are acquainted with only *one* case in which an instability of atoms makes its appearance and in which, therefore, the atom nucleus, itself, is decomposed: this is the case of radio-active bodies. Here, indeed, an alteration of the atom takes place—an alteration which involves the atom nucleus, since the alpha particle, which is emitted during the decomposition of most radio-active bodies is a helium atom, being indeed a helium nucleus. That is to say it has a double positive charge and is, therefore, to be considered as a helium atom which has lost both of the electrons revolving about it. This helium nucleus has previously been a constituent of the nucleus of the radio-active atom from which the alpha ray proceeded. It is through this alpha ray that we learn of the extraordinarily powerful forces which hold the nucleus together, for we know that in the alpha particle that is flung off from a radio-active atom there resides an energy which is extremely powerful in relation to its infinitesimal mass. This quantity of energy is so great that a single alpha particle, in spite of its extreme minuteness (1 cubic centimeter of helium gas contains 27 trillion atoms) occasions a flash of light which is visible to the human eye when it falls upon a luminous screen of zinc sulphide. From the point of view of energy the alpha particle, on account of its extraordinary velocity exceeds all our other physical aids to such a tremendous degree that it justifies the hope that it might be able to exert an influence by its action upon a suitable atom nucleus. *This is the essential principle upon which Rutherford's most recent work is based.*[1] *The chief result obtained thereby is the proof that when an alpha particle strikes a nitrogen nucleus a ray is liberated from the latter which apparently consists of a hydrogen atom.* The phenomena which make their appearance when alpha rays penetrate solid or gaseous bodies had already been thoroughly investigated by Rutherford and his followers. They also form an immediate starting point for the next development of the theory of the structure of the atom. The path followed by the alpha rays is, namely, in general almost a straight line; likewise the length of the path is a constant for alpha rays of a given velocity in a given medium. After traversing this distance, the so-called range, the alpha rays suddenly stop still in the absorbent medium. Alpha rays of radium C, for example, have a range of 7 cm. in the air. When the alpha rays are allowed to penetrate a denser body such, for example, as metallic gold, they undergo even in this case only a very minute deviation from their rectilinear path. It is only in very rare cases that there occurs a greater deviation even up to 90 deg. or more. This phenomenon definitely indicates that the alpha particle passes almost without hindrance through the cloud of electrons which surround the nucleus of the atom of gold on account of its mass which is very large as part of the electrons; and it also shows and also indicates that the alpha particle when it reaches the vicinity of the nucleus of the gold atom is strongly repulsed by the latter because of having a charge of the same kind and because of this strong repulsion it indicates a marked deviation. Since, however, strongly marked deviations occur with extreme rarity the extent of the gold atom nucleus must be very small as compared to the total diameter of the gold atom. Furthermore, since the charge of the alpha particle is known (equaling two positive elementary quantities) Rutherford was able to calculate the charge of the nucleus of the gold atom and of other atoms.

The newest experiments made by Rutherford are concerned with the collision of the alpha particle with the nucleus and the lightest known atoms: hydrogen, carbon, nitrogen and oxygen. They take their start from an observation made by Marsden who allowed alpha rays to pass through a hydrogen atmosphere. Marsden observed in this experiment that quite outside the range of the alpha rays other points of light (scintillations) make their appearance upon a zinc sulphite screen; these scintillations, however, are very few in number as compared to the number of the alpha rays employed by him. These scintillations can have their origin only in the hydrogen rays which are produced when the alpha particle directly collides with a hydrogen nucleus and imparts to the latter so great a velocity that it, itself, becomes a ray which produces a flash like that of the alpha ray upon a zinc sulphide screen. Since the hydrogen nucleus is only one quarter as large as the alpha particle (the atom mass of hydrogen equals one while that of helium equals four), naturally the velocity of the hydrogen atom which has come into collision is greater than that of the alpha ray. Consequently the aforesaid scintillations make their appearance beyond the range of the alpha rays.

D. Bose succeeded in obtaining a direct proof of the fact that such hydrogen rays are occasioned by the collision of alpha rays with hydrogen atoms, by photographing the paths of alpha rays in hydrogen by means of the Wilson expansion method. The path of an alpha particle which has collided with a hydrogen nucleus is shown as a bright streak on a dark background, for the photograph was taken in such a manner that at the instant when the alpha rays were allowed to enter by the withdrawal of the screen, the atmosphere of hydrogen being supersaturated with water vapor, a sudden cooling is created which causes water drops to be deposited upon the ions, which are formed along the path of the ray. At the same moment a powerful electric spark is released which brightly illuminates the droplets of water upon the dark background. The separate water droplets which indicate the path of the ray cannot be distinguished from each other. However, such effective collisions occur very rarely, since the alpha particle must strike the hydrogen atom very near the nucleus and the latter is, as we know, extremely small in relation to the whole atom.

Rutherford next made use of powerful radium preparations (having an activity up to 80 mg. of radium) in order to observe the scintillations in the hydrogen rays (usually called H rays) produced by the collision of the Ra-alpha-rays in hydrogen gas. Such observations are extremely tedious and troublesome since the scintillations produced by the H rays have a very faint light; moreover, the effective collisions capable of producing such rays occur very seldom—only one hydrogen ray is produced by the passage of 100,000 alpha particles through a stratum of hydrogen 1 cm. thick. It is necessary for the nucleus of the alpha particle and of the H atom to come within a few billionths of a millimeter of each other, whereas the diameter of the entire H atom, on the other hand, is not 0.1 millionth of a millimeter! It is also possible to produce H rays by the collision of the alpha rays passing through a thin stratum of paraffin (i.e. a compound of hydrogen). The relation of the charge to the mass in these H rays was determined by the measurement of the degree of the electric and magnetic deviability. These determinations demonstrated that the rays observed are, as a matter of fact, simple, positively charged hydrogen atoms.

Rutherford next attempted to find out whether such rays are formed in other gases than hydrogen by the collision of

[1]Phil. Mag. (6) 37, pp. 537-587, 1919.

alpha particles. According to theoretical calculations a greater range than that of the alpha rays themselves can be possessed only by rays which are obtained by means of a collision with light weight atoms up to oxygen inclusively. It is true, to be sure, that a collision of the alpha rays with the heavier atoms may cause rays produced by the collision to be emitted from these atoms, but in such cases the rays thus produced would have a smaller range than the alpha rays and would, therefore, elude observation among the very large number of the alpha rays having a normal range. In oxygen, nitrogen, and carbon-dioxide, however, Rutherford succeeded by the observation of the scintillations in discovering rays having a greater range than the X-rays themselves, and which must be, therefore, oxygen rays and nitrogen rays produced by the collision of the alpha rays with the nucleus of the oxygen atom and nitrogen atom respectively. These rays had a range up to 9 centimeters in air—a range 2 cm. farther, therefore, than that of the colliding alpha particles whose range is 7 cm. Their number, indeed, is still less than that of the H rays, since in a passage through 1 cm. of the medium of one million alpha particles only 7 nitrogen or oxygen rays are produced. This makes it easy to understand why these rays have hitherto escaped observation. Carbon rays such as might be produced by the collision of the alpha rays with the carbon atoms in carbon-dioxide have not yet been observed; such carbon rays would necessarily have a greater range (12 cm.) than the nitrogen and oxygen rays. But only oxygen rays made their appearance in the carbon-dioxide. The scintillations of the N rays and the O rays are brighter than those of the H rays, because the N atoms and the O atoms are larger than the H atoms.

A most surprising effect was observed, however, when Rutherford began to make observations in dry air or nitrogen *outside* the range of the N rays by means of a scintillation screen. Here, too, he found very faint scintillations which did not cease to appear until the distance of 28 cm. from the source of the rays was attained—a distance corresponding, therefore, to the range of hydrogen rays. In these experiments the most scrupulous care was taken that there should be no hydrogen either in the source of the rays or in the enclosing plates of the apparatus or in the shape of water vapor in the gases employed. The scintillations at once ceased also when the nitrogen or the air was replaced by oxygen or by carbon-dioxide. It was also found that the number of scintillations was increased by 1.25 fold when the air was replaced by pure nitrogen. It is evident, therefore, that the effect observed is connected with the nitrogen and hydrogen particles and that the phenomena observed can have their origin only in the nitrogen nucleus from which they are set free by collision with the alpha particle. The number of the H rays produced is very small: among 12 N rays produced by collision only one such abnormal H ray makes its appearance. Deviation tests in the magnetic field make it seem highly probable that the rays observed are genuine hydrogen rays, although the possibility is not excluded that they may be rays of the atoms of a hypothetical element having an atomic weight of 2.

THE DECOMPOSITION OF THE NITROGEN ATOM

In any case the extraordinarily important result of this experiment is the demonstration of the truth of the fact *that when a nitrogen nucleus is directly struck by an alpha particle (which of course is extremely seldom on account of the smallness of the nucleus) it is decomposed and the portion liberated in the form of a ray by the collision is apparently the nucleus of a hydrogen atom.*

The dream of the alchemist.—Thus we see that the enormous energy of the alpha particle really accomplishes, in this instance, the miracle which the alchemists of old sought in vain to attain—the decomposition of an atom. This result has been obtained, indeed by very different methods from those employed by them—we are working here not with the comparatively coarse macroscopic methods of chemistry but with the most delicately developed technique of observation which lays hold of the separate atoms, and among these chooses out of thousands or millions of cases precisely those which are of greatest importance.

Difficulty of the task.—We must not forget, therefore, in the brilliancy of the achievement of the breaking up of the nitrogen atom the conditions which the task involved and imagine, perhaps, that we shall now be able to work with these products of decomposition by ordinary coarse chemical methods. As a matter of fact the method of observation of the scintillations (at present the only one) is so wearisome in the exact sense of the word that the development of further investigation must necessarily be very slow. Rutherford himself declares that no one can perform this task of counting without injury to his health for more than one hour per day and that he can do this only by counting for one minute at a time and then giving the eye one minute of rest.

The importance of Rutherford's discovery of the possibility of the decomposition of nitrogen resides primarily in the confirmation of the possibility of the decomposition of an atom nucleus.

HYDROGEN A PROBABLE CONSTITUENT OF NITROGEN

Next to this, however, the indicated fact that hydrogen is probably a constituent of nitrogen is of great significance. This revives the old hypothesis of Prout that all elements are composed of hydrogen. On the other hand we know from the phenomena of radio-activity that the helium atom is a constituent of the radio-active atom. It is probable indeed that other atoms likewise possess the helium atom as a constituent, for the multiple of the figure 4 of the atomic weight of helium very frequently makes its appearance in the series of atoms. Moreover, this multiple of the figure 4 (or more exactly 4.002) need not be exactly fulfilled since according to the newest views the atomic weight is influenced by the greater or less amount of energy contained. We should, according to this, be obliged to regard the nitrogen nucleus as composed of three helium nuclei and two hydrogen nuclei (or a nucleus having the atomic weight of two) so that the atomic weight of the nitrogen would be represented by the expression 3 times 4 plus 2 equals 14. That the entire nitrogen nucleus is not composed of hydrogen nuclei is indicated by Rutherford's observation that in the collision of the alpha rays with the nitrogen nucleus 12 times as many nitrogen rays as hydrogen rays were produced, i.e. in most cases the nitrogen atom was not decomposed but only thrust farther away while it is comparatively seldom that a hydrogen nucleus is hurled forth from the nitrogen nucleus. This fact corresponds admirably with the view that the larger part of the nitrogen nucleus is composed of higher units than hydrogen—even of helium nuclei which give it, therefore, a more stable structure. It is very noteworthy, too, that no H atoms are liberated from carbon and oxygen. Carbon would seem to consist of only 3 and oxygen of only 4 of the difficultly decomposable helium nuclei. That the helium nucleus has a special rôle to play with the hydrogen nucleus is also indicated by the fact that the alpha particle which, as a matter of fact, represents a helium nucleus is not disturbed by its collision with other atoms. This can be explained by the supposition that the helium nucleus, together with the hydrogen nucleus, forms a special unit; it is far more probable, however, that the helium nucleus is composed of 4 hydrogen nuclei held together by extraordinarily powerful forces. Such forces can be yielded only by electrons which in consequence of their negative charge hold together the positive hydrogen nuclei. These then are *nucleus* electrons, which hold together the nucleus having the magnitude of a billionth part of a millimeter in contrast to the outer electrons of the rings which revolve about the nucleus at a much greater distance. Since the helium nucleus possesses the double positive elementary charge in the simplest conceivable case two electrons must hold together the four positive hydrogen nuclei, so that the helium nucleus

exhibits two positive charges outward toward the ring. That the helium nucleus is possessed of such a structure or an analogous one is also indicated by Rutherford's experiment concerning the collision of the alpha particles with the hydrogen nuclei which cannot be fully explained by charges in the form of points of the hydrogen and helium nuclei, and this accordingly indicates the *structure of the nucleus.*

The physics of the atom nucleus.—Thus the brilliant experiments of the distinguished English investigator have opened up a promising new realm of physics—the physics of the atom nucleus. It is our hope that that common work of the cultural people which is once more beginning to make its appearance, will soon yield fresh results in this interesting realm of thought.

Stabilized Governing

A "Dead Beat" Governor for Auto-Truck Radio Plants

By Oscar C. Roos

THE unsatisfactory performance of governors on small gas engines has not been sufficiently looked into until very recently. These gas engines did their work passably well until the electric generator was hooked up with them and then there occurred flickering in voltage in D. C. sets and change of frequency in addition, in A. C. sets. It goes without saying that an entirely new type of governor was needed for the many small electric power units required by the Army and Navy during the World War. Such a governor must work on a new principle if a speed regulation closer than ½ per cent is to be obtained between no load and full load.

The use of gas engines as closely governed as ½ per cent or even less is based on a principle which has been employed

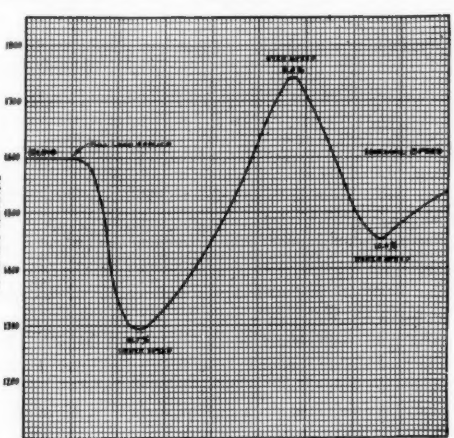


FIG. 1. TIME SPEED GAS ENGINE CARD WITH ORDINARY GOVERNOR INSTALLED

in water-wheel governors and in certain other cases where "hunting" in the governor would be serious. The accompanying engravings illustrate one form of such a governor, called a "precision" governor.

In Fig. 1 we have a time-speed gas engine card with the ordinary governor installed. The normal speed is 1,600 r.p.m. At the end of one second the full load is applied and in 1½ seconds more the speed has dropped 18.7 per cent. The governor by this time may be said to be "alive" to the situation and is overzealous, for in 2.5 seconds more it has restored the speed to 1,600 r.p.m. as shown where the curve crosses the original line. It does not stop here, however, but now raises the speed in one second more 8.8 per cent *above* normal. In one more second it is again at normal and then a second later is at 10 per cent below normal. So it goes, in smaller oscillations of speed, until finally 1,600 r.p.m. is reached after several oscillations. This kind of a performance might be allowable in a machine with infrequent changes of load but in an auto-truck or an electric and especially a radio power set it is out of the question.

What has been described above is generally known as "hunting," probably because the governor is chasing the engine in a vain endeavor to catch up with its demands. If the governor were incapable of oscillating it could not even be forced to hunt. In other words the successful governor must be "dead beat."

Now there are a number of ways to secure this, and to show the effectiveness of the result, using the methods and construction outlined further on, the time-speed curve of a gas engine with a precision governor is shown in Fig. 2.

The speed at the beginning of the test is the same as before, 1,600 revolutions per minute. At one second later, the full load is thrown on, and in .7 seconds the speed sinks to 5.6 per cent less than the normal, but the governor now acts in a different way from before. It acts very much more promptly in the first place, as it recovers full speed in 1.3 seconds and in the second place it does not noticeably "overshoot" this speed.

In other words, it rises above 1,600 r.p.m. in .5 seconds more by 5 revolutions per minute or about 1/3 per cent. It then sinks to normal in another half second and stays there. Com-

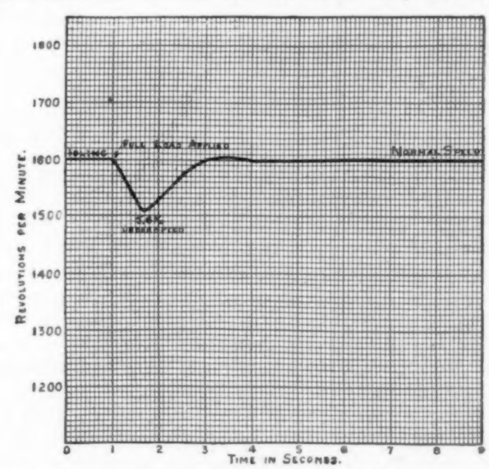


FIG. 2. TIME SPEED CURVE WITH PRECISION GOVERNOR

paring the two performances, the precision or stabilized governor is back at normal speed in 2 seconds while the unstabilized form requires from four to ten times this period in which to settle down again.

When 20 per cent of an engine tender's time is spent making repairs and adjustments on his carburetor, it is evident that he needs a governor which is independent of carburetor adjustment. The only time a governing mechanism acts independently of the fuel supply mechanism is when it is made "hunting-proof."

Many motor boats were used during the war as submarine chasers and had to have independent gasoline electric plants for their radio telegraph outfits. Such a class of vessels abso-

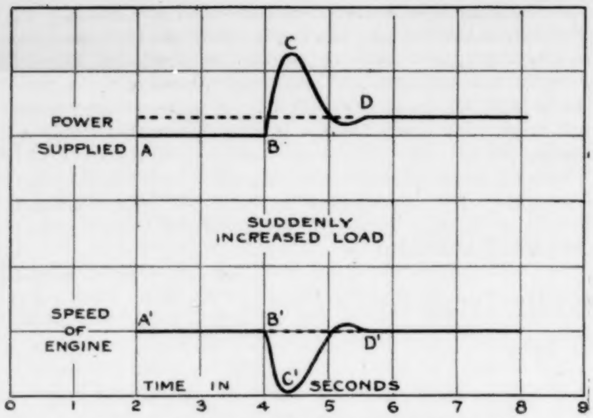


FIG. 3. POWER CHARACTERISTIC CURVES FOR PRECISION GOVERNOR

lutely required stabilized or "anti-hunting" governors to give precision in speed adjustments. The questions of load, ignition, adjustment, carburetion or quality of gasoline, or even temperature and humidity were of necessity, to be rendered immaterial. This is an interesting and difficult problem but has been solved by a precision mechanism. The usual governor is intended to keep a definite throttle opening at a certain speed. If the gasoline is bad, so much the worse for the governor, the same throttle opening is still held for a certain standard speed. In some cases all speeds will then have insufficient throttle openings and in order to get near normal speed again an undue opening is given by the governor with the result that the general operation of the power unit is very unsatisfactory. There are many engineers who refuse to consider this kind of a speed controller as a true governor at all.

Any precision governor not only controls the engine speed positively, but it selects the proper throttle opening to best effect the desired speed regulation. It is more than a controller. It is a real speed governor.

GENERAL PRINCIPLE OF STABILIZING GOVERNORS

1. When the motor speed finally *rises* to its *proper* value, the power finally *falls* to its *new* value.

2. When the motor speed finally *falls* to its proper value, the power finally *rises* to its *new* value.

The above two principles may be summed up in the general statement that the time power, or time fuel, and the time-speed motor characteristic curves must be similar in shape. Especially in their final stage should they be symmetrical with respect to each other. Each changes at about the same rate but in the opposite sense to the other.

Fig. 3 shows in detail the reason why the precision governor

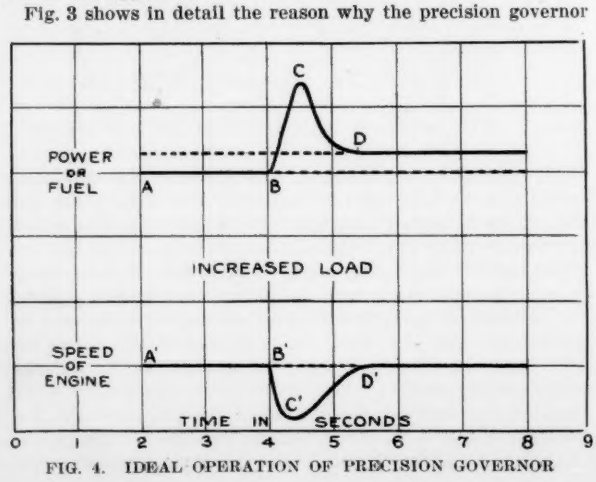


FIG. 4. IDEAL OPERATION OF PRECISION GOVERNOR

works as it does, to bring the power and speed of the engine from *opposite* states of excess or deficiecy, to a *balanced* condition.

The top curve shows the power (fuel) supplied, the lower shows the resultant speed. At B in the top curve let the load suddenly increase. The power immediately is increased to the value at C, much in excess of the final requirement shown at D. At the same time the speed has dropped slightly to C' but immediately recovers by *increasing* gradually as the C D power comes down *gradually*.

The above method of operation constitutes the *secret* of all precision governors. It also gives extremely quick action as compared with the ordinary governor. However, it always allows the power to settle down and "cushion" itself while the speed is rising at a constantly decreasing rate from C' to D', giving a "cushioning" effect also.

It is possible to regulate a governor of this type so that the differences in the shape of the curves from C to D and C' to D' will be practically undiscoverable, but this makes the governor almost too sensitive. Such governors should show the curve shapes sketched in Figs. 4 and 5.

Before going into the actual mechanical details of the stabilizing or precision governor, it is worth while to ask

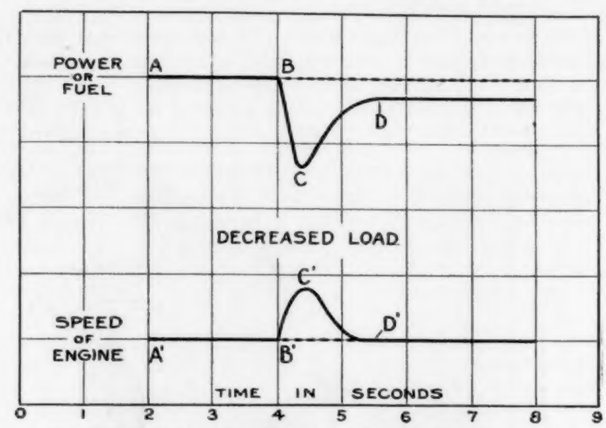


FIG. 5. IDEAL OPERATION UNDER DECREASED LOAD

exactly why the stabilizing governor works at all. In other words, why does the governor first do *too much* and do it very quickly and then in apparent contradiction of its first intentions, "reverse itself" and "repent" as it were of its exaggerated activity by undoing its work until the arrival of the motor at the proper speed stops the farther course of this "mechanical remorse"?

The simplest answer, short of the actual working diagrams, is to say that the instant one part of the governor—the speed control proper—starts to work to change the fuel there occurs a mechanical "tragedy." Another part of the governor—the "speed restorer"—immediately is thrown into gear with the motor and "strangles" the fuel control as it is doing its work. It does this by moving the control mechanism so that the governor speed control becomes *less and less effective.* In fact, it "dies in harness." Well, no harm is done, as its "death" exactly coincides with the attainment of the proper speed again. It is immediately ready for another attempt.

Let us now examine the precision governor itself. A diagrammatic sketch of one type, now superseded, is given in Fig. 6. This is also shown partly broken away in Fig. 8, which being in prospective gives a clearer idea of the operation of the governor. The principle of operation is the same as that of a later form shown in Fig. 7 with some minor exceptions, and will now be followed out in detail.

The central element in Fig. 6 is the driving shaft. This carries the two units or halves of the mechanism which in responding to changes of speed, really work against each other. The lower half carries the centrifugal speed controller—an

ordinary governor. The top part carries the true governing "speed restorer."

Examining the lower half we find the two governor weights C7 pulling down a channeled collar C5, running freely on the shaft against the spring C9. The slightest axial motion of the pin D5 working in the above collar channel moves the fuel adjusting pivot by means of the linkage D5 D8, D6 D7 and D1 D2. So far the operation is quite commonplace. It is the top part of the shaft that carries the real governing mechanism. There are two spirals cut on the inner faces of the spool C4. This spool normally revolves freely on the shaft, driven by a supporting clutch C10. This clutch raises the spool when the speed is too low and lets it drop *by its own weight* below the normal position when the speed is too high, except for certain conditions in which a return spring is added to secure positive operation.

There is a spur wheel E2 which engages with the spiral cut in the lower or upper inner face of the spool. It may be arranged to do this on the least variation in the position of fuel adjusting pivot D2 *again to the left,* thus *decreasing the already increased power gradually,* as shown in Figs. 3, 4 and 5, to its final proper amount.

There was a tendency in this type of governor to carry the member D3 off the shaft D4, so a locknut D9 was provided and the female thread in D3 was freed when the normal travel along D4 was exceeded.

There is a different precision governor on the market now in which a given travel of the Pin D2 gives a greater amount of power variation. Fig. 7 is an assembled view of a form suitable for auto-truck service.

In Fig. 9 the principal parts are shown. Part C is photographed upside down relatively to Part D. On part E a worm gear E9 has been indicated in ink. It drives the governing mechanism by rotating the fuel adjusting pivot D2 in a plane at right angles to the paper. There is no axial motion along a shaft, as in Fig. 6. The lettering and numbers of Fig. 9 have been kept similar to Fig. 6.

The novelty in Fig. 7 is found in the part D4, where the

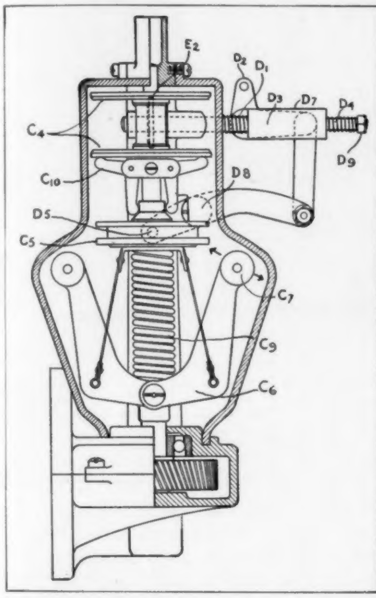


FIG. 6. DIAGRAMATIC SKETCH OF THE PRECISION GOVERNOR

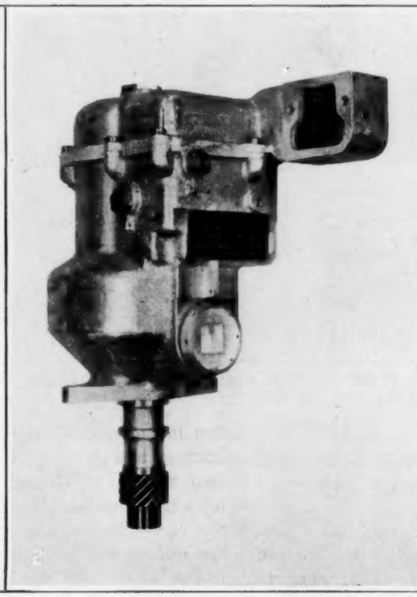


FIG. 7. ASSEMBLED VIEW OF FORM SUITABLE FOR AUTO-TRUCK SERVICE

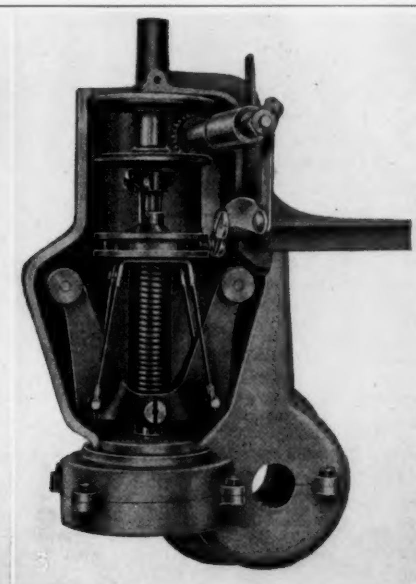


FIG. 8. SECTIONAL VIEW OF THE GOVERNOR SHOWN IN FIG. 6

C4. The more closely the diameter of E2 approaches the distance between the inner faces of C4 the more sensitive the regulation.

When E2 revolves, it does so in the plane of the vertical axis, that is, at right angles to the plane of the sketch, Fig. 6. It rotates a threaded shaft D4, so that the fuel adjusting pivot D2 is moved *in opposition to the motion derived through* D7, from the fact that the rotation of D4 moves D3—which *carries* D7 D1 D2—*bodily from right to left or vice versa.*

As soon as the spool action has governed the speed control on the lower part of the shaft this motion stops, since E2 and C4 automatically disengage themselves.

Let us trace out the action for a sudden load—see Fig. 4—and suppose that when D2 moves to the left it *decreases* the power of the motor.

1. The extra load comes on—the governor speed control weights C7 approach the shaft and allow the spring C9 to rise and actuate the clutch C10, which in turn causes the lower face spiral on the spool C4 to engage the spur wheel E2.

2. The channeled collar C5 moves up the pin D5 and thus moves the fuel adjusting pivot D2 suddenly to the right so as to decrease immediately the fuel and the power. It *overdoes this* and—

3. The shaft D4 is now rotated by E2 so as to bring the bodily transverse motion of D3 in Fig. 6 is replaced by the rotation of two friction-coupled metal disks in Fig. 7. Between these disks is brake lining material and the pressure thereon is adjusted by the spring D10.

The driving shaft D11 is supported in bearings shown at A11 in the housing and turns the driven element D3 until either of the two lugs thereon D12 engage the stop A12 in the housing. The shaft D11 now keeps on turning against the friction of the brake lining in D4 until the action of D2 has brought the motor to speed and disengaged E2 from C4 as in Fig. 6.

Some tests have been made by the International Radio Telegraph Company on this governor to show how perfectly it chokes off the worst possible tendency to run away and *immediately* brings the speed to normal.

The governor was set for 1,260 r.p.m. in all these tests. With no load on the engine, except driving friction, sudden admission of steam at full throttle gave 1,280 r.p.m. and in two seconds 1,260 r.p.m.

With half load the same thing occurred. With full load there was no noticeable rise in speed, as the governor was adjusted for full load conditions.

Suddenly removing the full load gave 1,400 r.p.m. for a moment and then 1,260 r.p.m. was immediately restored.

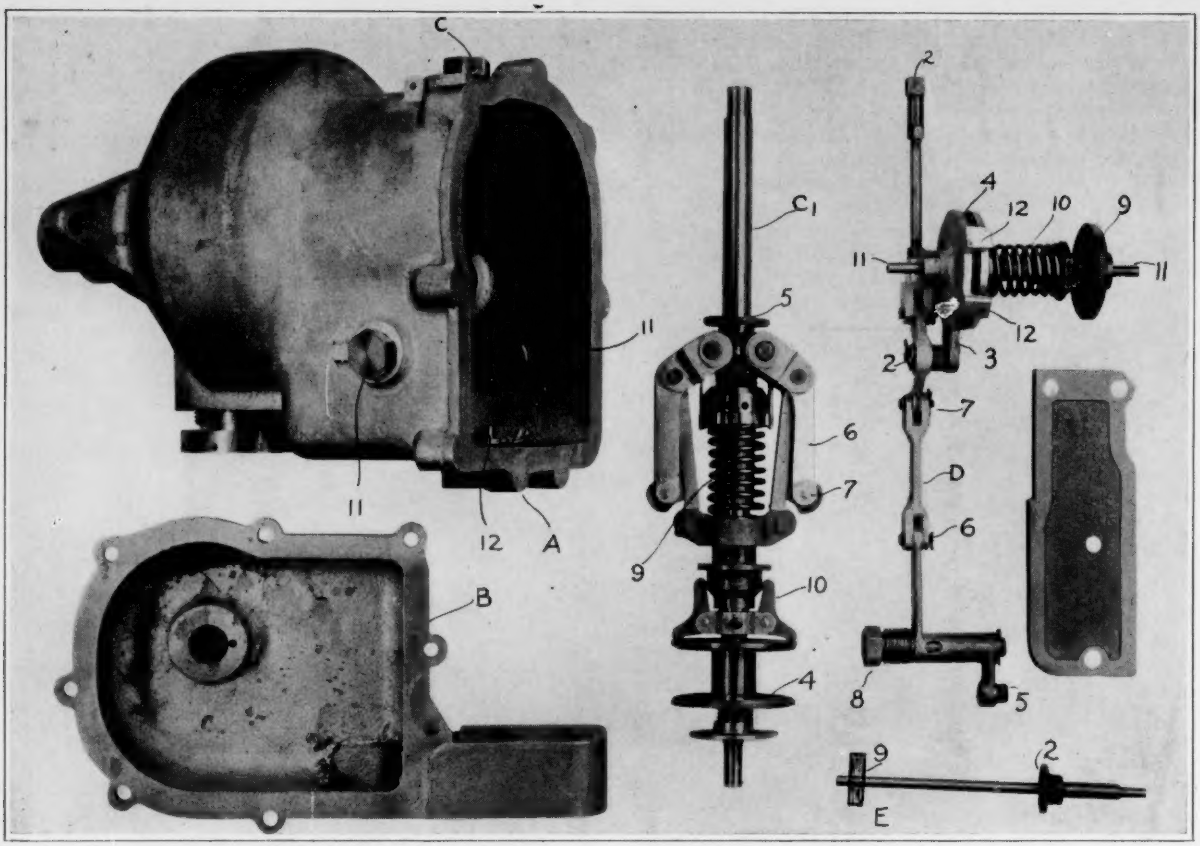


FIG. 9. EXPLODED VIEW OF THE FORM OF GOVERNOR SHOWN IN FIG. 7

With steam completely shut off tests were made by cutting in full load or "no load" and then by special arrangements, suddenly admitting a full head of steam to get a "run-away" if possible.

Results: With full load the speed rose to 1,310 r.p.m. and sank to 1,260 immediately. With "no load" or "friction load" the speed rose to 1,360 r.p.m. and immediately sank to standard!

Truly, an interesting governor.

THE STABILITY OF MOTOR OMNIBUSES

In view of the growth of the use of motor omnibuses for city transportation an editorial in *The Engineer* in reference to the safety of this type of vehicle becomes of considerable interest. It would appear that there have been within the past year a number of cases in England where motor omnibuses overturned and there is a growing suspicion that the motor omnibus is not quite as safe as has been assumed hitherto.

Among the causes of this alleged condition are mentioned the carelessness of drivers who learned to take undue risks in France, the bad conditions of the roads and the degree of overcrowding now permitted in the interior of the omnibuses.

These causes do not appear, however, to be capable of explaining some of the accidents and it would appear as if the real cause lay in the design of the omnibuses. As regards this latter, the motor omnibus used on the London streets is a vehicle weighing in service condition some 9,850 pounds of which weight a little over 64 per cent is in the chassis. It is capable of carrying without overcrowding, 36 people, representing on an average a load of 5,400 pounds so that when fully loaded weighs somewhere in the neighborhood of 6½ tons.

Its center of gravity in service condition, but without load, lies low down, being only about 44½ inches above the road surface and just a little above the level of the tops of the rear wheels. The gage of the wheels being 70 inches, it follows that the vehicle will recover itself if it is tipped up until the rear axle is lying at 38 degrees to the horizontal. When the omnibus is fully loaded the center of gravity rises to 62 inches above the road surface so that in this condition the maximum heel from which the vehicle will recover itself is 29½ degrees. These figures do not take account of the fact that the body is mounted flexibly on the chassis. On an actual test the yielding of the springs permitted the vehicle to be tipped when empty until the center line of the body was inclined at 46 degrees to the vertical.

It would appear, therefore, that the motor omnibus is quite stable when stationary. When it is in motion the angles of heel mentioned above are a measure of its stability so long as its course is a straight line. The critical test for the stability of the vehicle arises when centrifugal force comes into play during the rounding of a corner. Taking 30 feet as the radius of the curves and 7 miles per hour as the speed when rounding the corner, it would appear that the stability of the omnibus is reduced by a little over 18 per cent, and if the vehicle carries passengers on the top only the loss of stability is a trifle over 19 per cent. Under these circumstances the critical condition of equality between the upsetting moment and the righting moment will be reached if the heel amounts to 23¼ degrees with the vehicle fully loaded or 22½ degrees if the passengers are entirely on the top. These angles would be reached only if the wheels on the inner side of the curve were lifted off the ground to a height of about 27 inches.

It would appear, therefore, that the stability of the modern motor omnibus is satisfactory and that such accidents as have occurred have been due to exceptional conditions.—*The Engineer*, Vol. 129, No. 3355, April 16, 1920, pp. 401-402.

The Dynamics of Shell Flight*

Experimental Determination of the Reaction of Air on a Moving Shell

By R. H. Fowler

THE object of this article is to give a short account of some features of the motion of a spinning shell through air. Our knowledge of this phenomenon has been somewhat increased by war-time researches. To determine the motion of a shell from the equations of rigid dynamics, we require to know the complete force system which represents the reaction of the air on the moving shell; but, just as in the case of an airplane, the components of this reaction are utterly unknown *a priori*. The problem that arises, therefore, is that of determining these components by observation and analysis of the actual initial motion of shells. Once they have thus been determined, they can be applied, provided the essential conditions remain similar, to the calculation of the complete motion of a shell along is trajectory.

In the simplest case of all this procedure is classical. The air resistance to a shell, moving so that the directions of its axis and the velocity of its center of gravity coincide, has long been determined thus as a function of the velocity, and trajectories have been computed assuming that this coincidence subsists throughout the motion. Under this assumption the problem is merely one of particle dynamics, of which the solution may be regarded as completely known. The comparison of calculations and observations shows good agreement in range and height when the shells are suitable and the total angle turned through by the tangent to the trajectory is less than, say, 50°. The calculated trajectory, however, is a curve lying in the vertical plane containing the original direction of projection, while the observed positions of the shells do

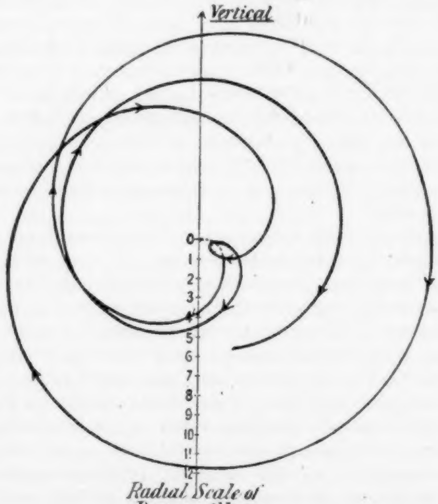


FIG. 1. OBSERVED PATH OF THE NOSE OF A SHELL. MUZZLE VELOCITY 1565 F.S. RIFLING 1 TURN IN 40 DIAMETERS OF THE BORE

Total time taken to describe curve shown 0.38 sec.

not lie in this plane, but appreciably to the right of it when their axial spin is right-handed. This well-known departure from the original vertical plane is called *drift*, and converts the trajectory into a twisted curve. It cannot be accounted for on the original assumption.

It is with these cases, in which particle dynamics fails to explain the observations—such as the drift, trajectories of large total curvature, and (as we shall see) initial motions—that we are mainly concerned here. For their study we must abandon the assumption that the direction of motion of the center of gravity and the direction of the axis of symmetry coincide, and study the whole motion as a problem in rigid dynamics.

In order to do this we must, first of all, determine experimentally the complete reaction of the air on the moving shell when the directions of its axis and the motion of its center

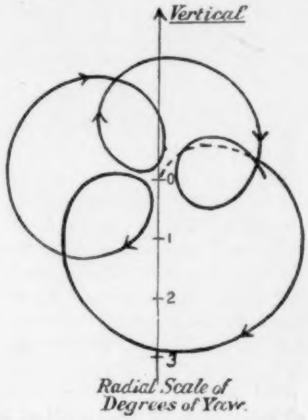


FIG. 2. OBSERVED PATH OF THE NOSE OF A SHELL. MUZZLE VELOCITY 1563 F.S. RIFLING 1 TURN IN 30 DIAMETERS OF THE BORE

Total time taken to describe curve shown 0.20 sec. The scale is three times that of Fig. 1.

of gravity no longer coincide. In such a case the angle between these two directions is called the *yaw*. Until recently the reaction on a yawed shell had never been studied experimentally. The necessary data, however, can be obtained by observation and analysis of the initial motion of the shell in the first few hundred feet after leaving the muzzle of the gun, for in this interval the axis of a shell oscillates periodically over an appreciable range of yaw.[1] The motion is a little complicated, and its interpretation is not yet completely worked out in terms of the reaction of the air. Moreover, a really satisfactory experimental method has not yet been devised. But a start has been made on the problem, and approximate values of the more important components have been determined.[2]

The somewhat crude experimental method so far used consists in firing a shell through a series of cardboard screens. The shape of the hole in the card determines the size and direction of the yaw at the instant of passing through the card. From such observations the motion of the axis can be plotted out against the time (if the velocity of the shell is known), and the period of its oscillations determined. The disturbing effect of the cards themselves can be determined by suitable control experiments and roughly estimated. Two specimen observed curves[3] traced out by a point on the axis of the shell relative to the center of gravity are shown in Figs. 1 and 2. These two paths are strictly comparative, as the only difference between their circumstances is an alteration of the axial spin. The slowly spinning shell (Fig. 1) has

*Reprinted from *Nature* (London), June 3, 1920.

[1] Such experiments are described in a forthcoming paper in the Royal Society Transactions by R. H. Fowler, E. G. Gallop, C. N. H. Lock, and H. W. Richmond.

[2] The forces on a model shell at rest in a steady current of air of low velocity can also be measured directly in a wind channel; the results are probably applicable to a shell moving at velocities up to 700 f.s.

[3] The observations were made for the Ordnance Committee at H.M.S. *Excellent*, Portsmouth.

oscillations of comparatively long period and large amplitude. These curves are closely analogous to the curves which represent the oscillations of a spinning top near its vertical position. They differ only in showing slight damping and variation of period.

Let us consider further this analogy between a shell and an ideal spinning top. The center of gravity of the shell and the point of support of the top are analogous; so are the moments of inertia about these points and the axial spins. To the direction of motion in the case of the shell corresponds the vertical in the case of the top; to the disturbing couple due to the reaction of the air on a yawed shell corresponds the gravity couple on a displaced top. The analogy so far is practically exact; it is modified by the following facts:

(1) That the center of gravity is not a fixed point like the point of a top, for its velocity varies both in magnitude and in direction under the reaction of the air; it describes a helical curve, thus modifying the couple.

(2) That an appreciable frictional couple exists which, in conjunction with the helical motion of the center of gravity, serves to damp out the axial oscillations completely.

(3) That, in addition to (1) above, the magnitude and direction of the velocity of the shell are steadily altered by gravity.

Experiments so far carried out have determined approximately the values of the couple analogous to the gravity couple for velocities from 900 f.s. to 2,200 f.s. for two different shapes of shell, when the yaw is not too large. By determining these couples for various different positions of the center of gravity, rough values of the resulting sideways thrust on a yawed shell were deduced.

The study of initial motions is intimately connected with the question of the *stability* of a spinning shell at zero yaw. The motion of a shell (or a top) is said to be stable if a small disturbance only produces a small maximum displacement from the position of symmetry, proportional to the disturbance. The condition of stability for small disturbances is the same in the two cases; it must be fulfilled in order that the shell may travel along its trajectory approximately at zero yaw as desired. A knowledge of the disturbing couple enables us to lay down how much spin is required to allow a reasonable margin of stability.

We have said that the usual approximation of motion at zero yaw is inadequate in the case of trajectories of large total curvature. The complete theory indicates that, under the effect of gravity (see (3) above), the yaw tends to attain a sort of equilibrium value which increases along the trajectory, and may reach 20° or more at the end of a sufficiently long arc. A study of initial motions with slightly unstable shells in which such values of the yaw can be realized experimentally will provide the material required for the proper discussion of such trajectories.

The following approximate theory accounting for the drift of a shell has long been known. Owing to the change of direction of motion due to gravity (see (3) above), a shell cannot continue to move steadily at zero yaw. The proper equilibrium state of affairs is attained when the yaw is just such as will enable the axis to keep pace with the changing directions of motion by precession about it. This equilibrium value of the yaw depends on the above-mentioned disturbing couple due to the reaction of the air, which may be determined by a study of the initial oscillations. The resulting yaw in ordinary cases is too small to alter seriously the range at any given time, and does not affect the height because the equilibrium position of the yawed axis lies in a plane which is always very nearly at right angles to the vertical plane containing the original direction of projection. It produces, however, the lateral deviation known as drift. This approximate theory leads to a formula for the drift depending on the ratio of the sideways thrust to the disturbing couple. With the values of this ratio recently roughly determined, the drift has been calculated by this classical theory, and compared with direct observations of the drift of similar shells. The observed and calculated values are in fair agreement, and there is no doubt that the classical theory is substantially correct.

In conclusion, it is perhaps worth mentioning that the interest in such investigations mainly arises from the fact that we can thus study the phenomena of motion through a compressible fluid at velocities both greater and less than the velocity of sound in the fluid. The investigation, however, has scarcely begun, and much work will be required before it is possible to describe adequately the complete reaction on a shell of given shape moving through air.

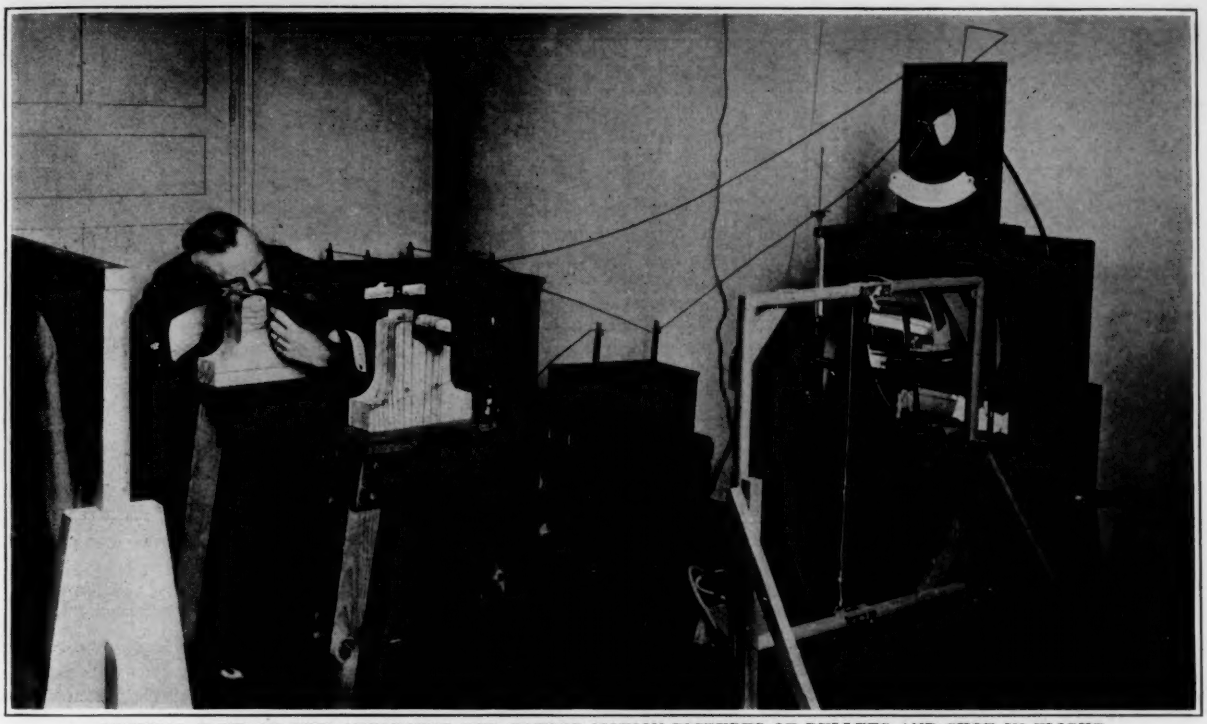
BRIQUETTING

In *Chemical and Metallurgical Engineering* for June 2, page 1034, a discussion of an experimental briquetting plant is presented by A. L. Stillman. Briquetting to most people is associated only with certain kinds of fuels, more particularly conversion of waste anthracite into the square briquette. Wherever a fine material is produced and there is something to be gained in returning it again to a larger size there is an opportunity for briquetting research, and this is a field in which a comparatively small amount of work has been done. In the metal industry there are numerous cases where fine ores and flue dust are a detriment to the operation and these can frequently be minimized through briquetting. When otherwise waste metals are to be fed to furnaces briquetting enables them to be used economically. If added in the form of punchings, unbriquetted, much of the metal is lost through too rapid melting and subsequent volatilization. In screening fuels there is sure to be a quantity of fine particles which with proper binders can be made very useful, particularly for domestic purposes.

Obviously, such a variety of raw materials cannot be handled successfully by a single process, so there is a need for specialized research in briquetting and this research should go beyond the laboratory stage. The provision of the experimental briquetting plant in question is, therefore, one which is welcome and from it a deal of constructive work should issue. There are a number of commercial briquetting plants in the country, varying from briquetting of steel turnings at the rate of 16 to 20 briquettes per minute, these weighing from 12 to 20 pounds each, to anthracite coal finds in plants with capacities up to a thousand pounds per day. Another plant briquettes an average of 8 tons of iron flue dust per hour, and abroad peat, lignites and sawdust are said to be successfully briquetted.

Sometimes materials may be briquetted without a binder and when binders must be used there is a variety from which to choose. Occasionally something must be added to accelerate the cementing action in the material so that it will bind under pressure. Then the proper pressure must be determined and often briquettes must be given after-treatment to toughen or harden them or make them water proof. Where metals are concerned lime is sometimes added to secure a binding effect and add smelting value to the briquette.

The following record of experimental work so far undertaken indicates something of the range of briquette possibilities. Ground phosphate, previously co-minuted with a small percentage of water, and lignite after carbonization have been briquetted successfully on a rotary press, the latter after mixing and mastication with oil residuum binders. Hard steel after annealing has been briquetted, as has hard bronze. Copper cement has required no preliminary treatment, while tin ore has been briquetted with a pitch binder. After heating at a low temperature, metal leaf and paper have been briquetted on a horizontal press, and with a lime binder complex copper ores have made satisfactory briquettes after a subsequent hardening in steam for three and a half hours or twenty-four hours of air drying. When shot nickel had been mixed with sulphite pitch in a pug mill it could be successfully briquetted in a horizontal press, and in the same type of press hard wood sawdust without preliminary treatment has been made into good briquettes.



GENERAL VIEW OF THE APPARATUS FOR TAKING MOTION PICTURES OF BULLETS AND SHOT IN FLIGHT

At the left, the lens which focuses the light rays on the camera which is out of the field of the photograph; *at the center,* operator aiming at wires in the stand in the foreground at the right; *in the background at the right,* the reflector and the spark producing apparatus

Shooting Flying Bullets with a Camera

Further Facts Regarding Dr. Bull's Investigations with the Ultra Rapid Cinematograph

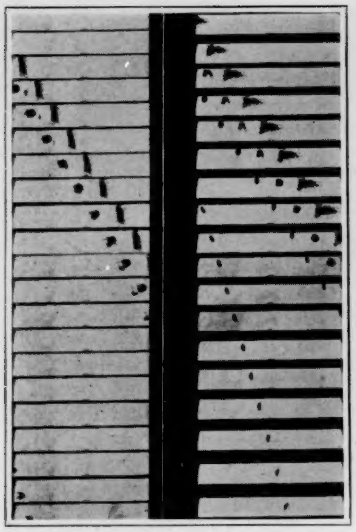
Photographs Copyrighted by A. N. Mirzaoff

THE remarkable new process by which ultra-rapid photographs of objects moving at high velocities can be secured, was described in the March issue of the SCIENTIFIC AMERICAN MONTHLY, but since fresh information has come to hand concerning the apparatus, we wish to give our readers the benefit of an enlarged account of this wonderful and valuable invention, which has made it possible to make motion pictures even of the flight of a bullet. We are indebted for our data to an article by Jacques Boyer in *La Nature* (Paris) for June 19, 1920. We refer our readers to our March issue for diagrams of the electrical equipment employed by the inventor, Dr. Bull, sub-director of the Marey Institute in Paris, for studying ballistic phenomena, and of the optical and photographic system employed by him. When it comes to taking moving pictures of rifle and revolver bullets traveling at a rate of 2,000 feet per second, or of shells moving through the air with a velocity of from 2,500 to 3,000 feet in the same length of time, the problem is far more complicated than in the case of taking ordinary moving pictures of men and animals in motion. If an ordinary photographic apparatus has its lens open for only *one ten-thousandth of a second,* during the passage of a projectile from a gun across its field the said projectile will have traveled in that brief space of time over a distance of nearly two and one-half inches and will leave only an indistinct shadow upon the plate of the camera. It is necessary, therefore, greatly to shorten the time of exposure in order to be able to apply photography to the study of ballistic phenomena.

Since there is no mechanical device capable of operating so rapidly physicists have had recourse to electricity for this purpose. The first step was the invention of special electric apparatus capable of producing a spark at once very brilliant and of very short duration. Consequently the electric circuit in which the said spark makes its appearance must possess large capacity and an extremely small induction. Furthermore, in order to obtain the spark at a given moment, the projectile itself is made to close the circuit.

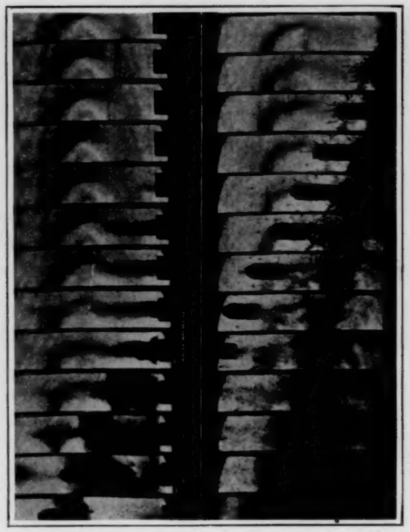
We owe the first idea of such experiments to Dr. Mach, a professor at the University of Prague, and the date was 1881. But it was not until 1884 that the Bohemian savant, assisted by his pupil, Wentzel, succeeded in obtaining distinct photographs both of a projectile and of the sound wave in the air produced by the electric spark. However, he found it impossible to record the wave of condensation of the air preceding the projectile, and since he ascribed this partial lack of success to the low initial velocity of the ball (800 feet per second), which was the highest rate he was able to obtain in his city laboratory, he begged his colleague, Prof. Salcher of Fiume, who was better equipped for such investigations, to continue his researches according to a definite programme outlined by him. Salcher, together with Prof. Riegler, undertook the work, and succeeded in 1886 by the use of Mach's method, in obtaining very small photographs, 3 or 4 mm. (0.118 to 0.157 inches) in diameter and representing bullets fired from different guns at various initial velocities (812 to 982 feet per second).

Ten years later C. V. Boys, of the Royal Society of London, repeated these experiments. By means of a spark flashing in the open air, without any optical apparatus or even a lens, he projected upon a sensitive plate the shadow of bullets moving at a rate of 1,100 feet per second. These records enabled him to make some interesting observations upon the movements of projectiles and gases. The same subject was taken up by various others, including Cranz and Gen.



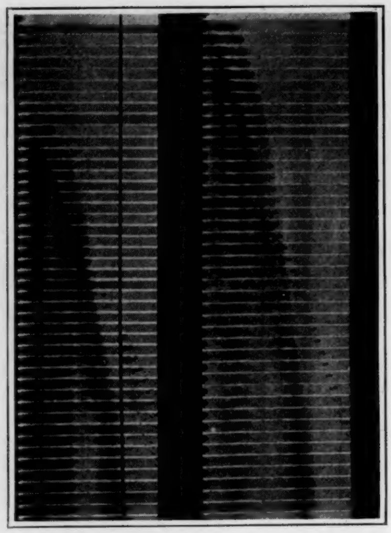
FLIGHT OF BIRD-SHOT FROM A SHOT GUN

At the left, smooth bore; *right,* "choke" bore. Note the "wads" following the shot.



FILMS OF A 37 MM. SHELL IN FLIGHT

At the left note air wave preceding the shell; *right,* powder grains around shell.



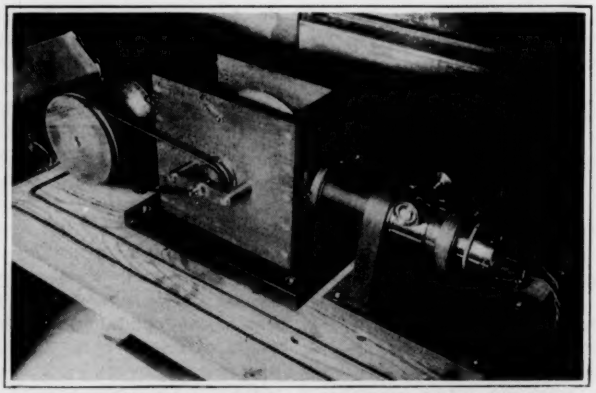
FOLLOWING THE FLIGHT OF REVOLVER BULLETS

Note how the projectile lags behind the powder gases and then overtakes them.

Journée. During the war M. Lucien Bull, at the request of the Bureau of Inventions, made new studies of ballistic chrono-photography, which we will here briefly describe:

Like his predecessors, he employed electricity as the source of light. The spark flashes in front of a concave mirror at a point situated upon the principal axis, in such a manner that the rays converge after reflection in the lens of the camera. The entire surface of the mirror is thus illuminated by the spark, and since the projectile traverses the beam of light it silhouettes itself thereupon. Hence by producing a series of sparks at very brief regular intervals, and causing the sensitive film upon which the successive images of the projectile record themselves to move at high velocity, it is possible to secure chrono-photographic pictures of the various phases of the phenomenon.

It is unnecessary to repeat here the description of the electrical apparatus which appeared in the previous article above referred to. Sufficient to say that sparks of a duration of less than a millionth of a second are obtained. In this brief interval our revolver bullet cannot travel more than 1/40 inch. The frequency of the sparks may be raised to as high as 50,000 per second, a blast of air being used to prevent the formation of a continuous arc.



THE CAMERA WITH MOTOR-DRIVEN FILM DRUM CAPABLE OF TAKING 15,000 PICTURES PER SECOND

The chrono-photographic apparatus consists of a wooden box hermetically sealed and fitted with an objective lens. Inside this box is a light cylinder of duraluminum capable of being revolved by means of an electric motor at a rate of 12,000 revolutions per minute. A sensitive film is rolled upon this cylinder, which, mounted upon a horizontal axis, successively presents every point of its circumference to the focus of the lens. The film therefore attains a velocity of 100 m. (328 ft.) per second, which permits the recording during this short lapse of time of 10,000 images 1 cm. in diam., or of 20,000 images 5 cm. in diam. Finally, a shutter is placed between the lens and the film in such a way that it is possible to operate in daylight. Electric circuits directly control the opening and closing of the shutter at the beginning and end of the phenomena.

Whether we are concerned with 37 mm. guns, with rifles, with shot guns, or with revolvers, the apparatus do not differ to speak of. For the first, however, M. Bull operated in a bomb-proof structure outside the buildings of the Marey Institute and the projectiles bury themselves in a turf covered target some distance away. Rifle and revolver balls are fired inside a room where there is a sand box to catch them.

A direct electric contact is established on the very trigger of the weapon for the purpose of controlling the shutter. The latter opens during the discharge of the power and the recoil liberates the sparks. Furthermore, a small but heavy mass, which slides freely inside a tube attached directly to the gun bears a pointed rod at its forward end. Before the experiment a thin insulating sheet separates this point from a lead contact likewise attached to the gun, but electrically insulated from it. When the shot is fired the lead contact, after piercing the insulating sheet, attaches itself to the point of the little mass, which does not stir, because of its inertia. Then the circuit, connecting the large condenser with the ignition apparatus at once closes, while the series of sparks begin. The wooden frame, which may be seen at a short distance in front of the operator, serves to locate the operations. It bears two conducting wires situated outside the field, but in the firing axis, and which are cut by the projectile. The rupture of the first arrests the sparks and that of the second closes the shutter.

The phases of the phenomenon are seen clearly in the films recording the 37 mm. guns (5,000 exposures per sec.). We observe first the appearance of the gaseous ring due to the air driven out by the explosion. This is formed at about 70

cm. (27.5 inches) from the gun, from which it recedes in widening circles at a velocity of 60 m. (about 200 ft.) per second. Next come the gases of combustion which fuse around the projectiles. Then the latter is seen instantly followed by the great mass of gas, and fourthly we see small sparks (probably ignited power grains) around the shell.

Shot gun films show the grouping of the shot at its exit. They are scattered coming from the smooth bores of ordinary shot guns, but more compact coming from "choke bores."

In the revolver film the images were made at the rate of 13,000 per second. We see first the end of the gun at the left, then the gases swirling around the bullet, whose velocity is very great at first, rapidly grows less. As soon as the projectile is quite out of the gun the gases escape and pass the projectile enveloping it in a fuliginous cone. When they lose their velocity the ball passes them and once more becomes visible at a distance of about 6 in. from the mouth of the gun. A little farther on the projectile passes through a thin pin board the splintering of which may be seen to the right and the left of the bullet and curiously enough some of these splinters have a velocity exceeding that of the projectile.

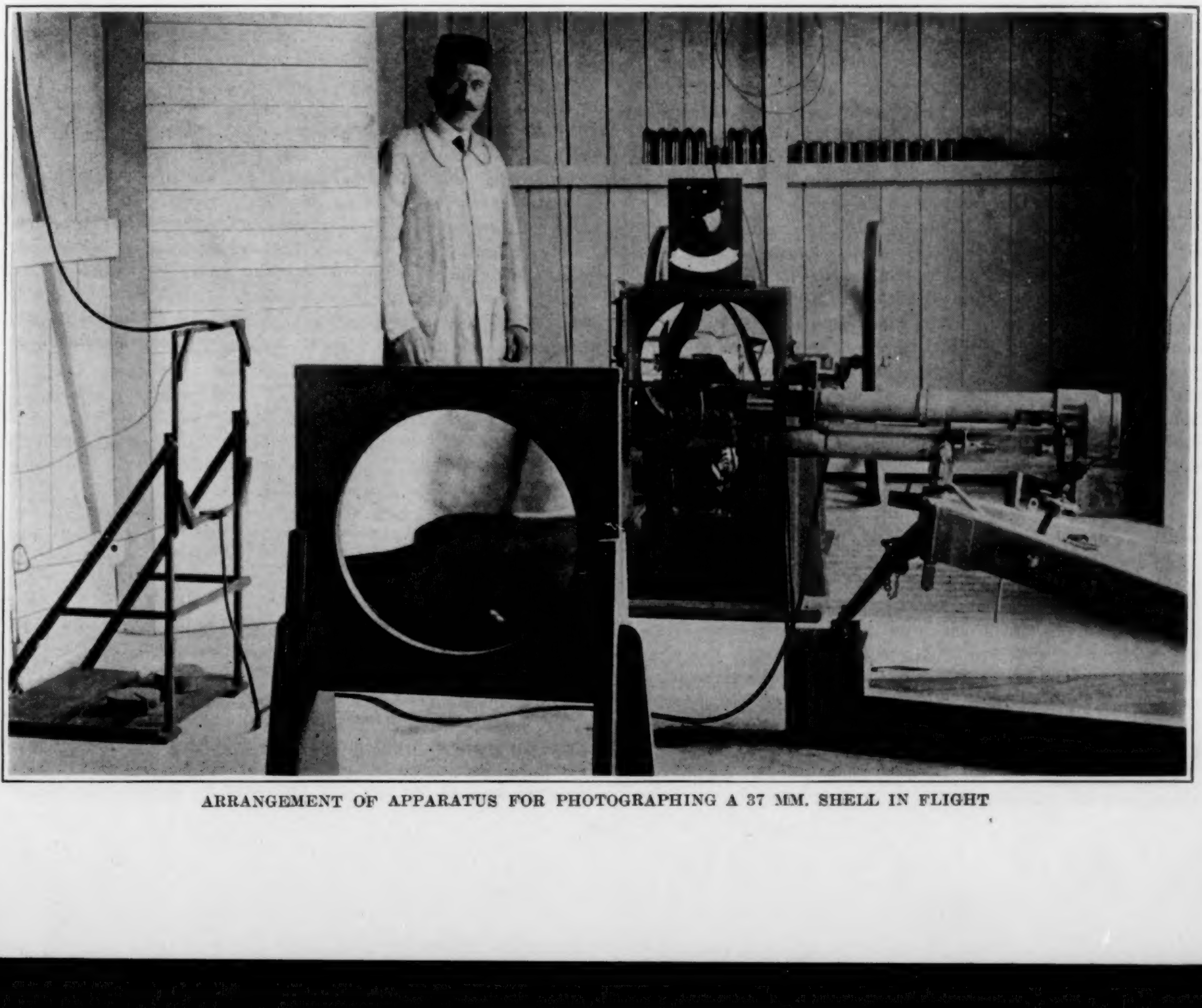
ABSORBING POISONOUS GASES WITH EARTH

When the Germans first launched poisonous gases as a weapon some of the soldiers at the front observed that the ground possessed a certain power of absorption with respect to such toxic blasts. At the suggestion of a French patriot, M. Hanriot, who furnished the means of pursuing the investigation, MM. Griffon du Bellay and Hudard, undertook to investigate the subject. The results of their studies were presented before the French Academy of Science January 26, 1920.

The first experiments made consisted in breathing for a period of thirty minutes air first saturated with bromide of benzol and then filtered through a layer of vegetable earth or humus, 10 cm. thick. This experiment having been successful others of a more precise character were undertaken in the Laboratory of the Government Bureau of Inventions erected under the direction of M. Lapicque. It was found that such earth retains the bromide of benzol, the oxychloride of carbon and also chlorine gas. This absorbing power is practically nil in cases of sandy earth, but increases in proportion to the amount of vegetable debris contained in the soil. For example, if one causes a mixture consisting of 30 parts chlorine with 70 parts of air to pass through 10 cm. of crushed soil at a rate of 12 ccm. per minute per square centimeter of surface it is found that the chlorined does not make its appearance at the exit from the filter until after a lapse of two hours and twelve minutes. In this instance the earth absorbed 1.50 gr. of chlorine per square centimeter of the surface of the filter.

M. Lapicque afterwards conceived the idea of making use of this absorbent power of humus for the better protection of troops in the shelters occupied during the gas attacks. The polluted external air was forced to pass by means of a ventilator through an earth filter which purified it, thus allowing the troops to dispense with masks in these shelters.

The figures given above refer to filters containing earth "in a state of repose," i.e., earth which was not renewed during the experiment, but it was found by M. Legrade, who continued the experiments of the previous investigators in the same laboratory that the gaseous mixtures contrive to filter only by means of a very small number of channels—these being those of least resistance. The toxic gas, however, made its appearance at the exit as soon as the molecules of earth forming the walls of these channels were saturated, and it was at this moment that the experiments described above were arrested and their results given out. It was only necessary to shake the filter slightly in order to displace these saturated particles of earth and replace them by fresh ones still retaining their power of absorption. M. Legrande made the important discovery that peat not only possesses the same properties as humus, but to a much higher degree.



ARRANGEMENT OF APPARATUS FOR PHOTOGRAPHING A 37 MM. SHELL IN FLIGHT

The Interference of X-Rays*

Vibratory Nature of Röntgen Rays Proved by an Ingenious Experiment

By Dr. K. Siebel

FOR a long time after the momentous discovery by Röntgen in 1895 of a new kind of rays, their nature was very uncertain. All hitherto known rays have been regarded as caused by the rapid vibration of the ether which fills all space, and as being therefore ether waves. Only one kind of rays, namely, cathode rays, were necessarily regarded as being material rays, i.e., as a homogenous current of minute particles of matter being hurled forth with tremendous velocity. Today, however, we know that the cathode rays, in other words, the rays which proceed from the negative electrode of a vacuum tube are nothing but electrons, i.e., particles of electricity hurled from the cathode under the pressure of a high electric tension. That part of the glass wall of the tube upon which such cathode rays strike under the influence of heat and of the fluorescence of the glass wall is the starting point of the X-rays or Röntgen rays which possess such a remarkable capacity for penetrating matter. Since there is a great similarity, however, between cathode rays and X-rays in several other points such as the exciting of fluorescence, the imparting of conductivity to the air, a strong chemical effect, etc., authorities were inclined for some time to regard X-rays also as being a sort of material rays, or, in the more usual term, corpuscular rays. However, the idea has steadily gained ground that X-rays are really waves of ether. Since, however, they exhibit neither regular reflection nor refraction like ordinary light in the usual mediums it was necessary to suppose that we are here dealing with waves only about 1 ten-thousandth as long as ordinary light waves. An attempt was made to express this stupendously brief duration of vibration by means of the following concept as to the origin of X-rays. When the electron, i.e., a particle of the stream of electrons issuing from the cathode with a rapidity approximate to that of light strikes the glass wall of the vaccum tube the said electron is suddenly checked or "braked" in this rapid motion. Since now every electron is, as a negative electric particle constantly surrounded by a field of electric lines of force which radiate in every direction like the radii of a circle, the said lines of force do not instantaneously come to a state of rest when the electron is suddenly checked but are so checked only after an immeasurable lapse of time. This checking of the lines of force naturally begins at the point where they are in contact with the electron and proceeds in the form of a broken wave. This interrupted wave of the lines of force imparts to the surrounding ether which is in a state of rest an impulse which continues as a sort of "push" or impulsion wave which constitutes the X-ray. In spite of this very probable explanation of the wave nature of the X-ray there was long lacking an actual proof of it, since no way had been found to show experimentally a refraction and especially a deflection of the X-ray.

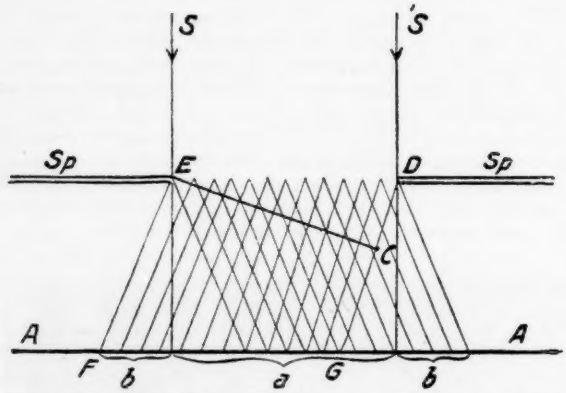


FIG. 1. S S, PARALLEL BUNDLE OF LIGHT RAYS; Sp, THE SLIT; A, ENTRANCE SCREEN. *a*, LIGHT PASSING THROUGH DIRECTLY; *b*, AREA OF INTERFERENCE LINES. RAY DG LINGERS BEHIND EF AT DC; THE SCREEN AA MUST BE CONCEIVED OF AS BEING SPREAD MUCH FARTHER APART SINCE THE WIDTH OF THE SLIT IS BY FAR TOO LARGE AS REPRESENTED

If an ordinary bundle of parallel light rays (Fig. 1) is allowed to pass through a very narrow slit so as to fall upon a screen placed behind the said slit, there is observed upon either side of the bright strip of light corresponding to the crevice through which the light rays have passed a series of alternating bright and dark lines which are known as lines of interference. The same phenomenon can be observed in a very beautiful manner if a fine cut is made in a sheet of paper and then a source of light observed through this aperture. Lines of interference are caused by the fact that the waves of light are deflected to one side at the edges of the slit exactly in the same manner as waves of water are deflected by a floating piece of timber. This occasions a difference of phase in the separate groups of waves with respect to each other. . . . And when this difference of phase, i.e., the difference in the state of vibration is exactly enough for the crest of one group to compensate the trough of the other, the vibration ceases and a dark interference line is produced. When the width of the crevice is very large with respect to the length of the wave, somewhat more than 0.1 mm. these interference lines are so faint that we are no longer able to see them.

The difficulty was in proving that these phenomena were likewise exhibited by X-rays, since we possess no mechanical means of making a slit narrow enough for waves of such exceedingly short lengths. At this juncture the following brilliant thought occurred to the physicist Laue. In the generally accepted opinion crystals differ from non-crystallized bodies essentially in the fact that the separate molecules possess a definite arrangement in space (Fig. 2). Since we are obliged to consider the distance apart of such molecules to be about 0.01 $\mu\mu$, i.e., 0.00000001 mm. it is evident that the free space between two such chains of molecules forms an

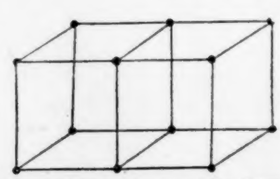


FIG. 2. DIAGRAM OF SPACE LATTICE

ideal crevice of infinitely small width and with such a crevice it would be possible to make evident the deflection and interference of X-rays provided they are really ether waves. Since, however, we possess in a plate of crystal not only such a crevice but a whole series of such crevices parallel to each other and crossing each other at an angle, it must be true that we could obtain (as can likewise be demonstrated with ordinary light) an entire field of such interference phenomena around the ray and not merely on one side and on

*Translated for the *Scientific American Monthly* from *Kosmos* (Stuttgart) for February, 1920.

the other, as in the case of a single crevice. Since, however, there are many parallel rows in such a checkerboard framework or special lattice as is represented above, these spots will be able to make their appearance only in certain definite directions, whereas they will be nullified at other places by coincidence with the places of smallest effect.

This theory of Laue was tested experimentally by Friedrich and Knipping, by causing a narrow bundle of X-rays passing through a lead screen and through a zinc sulphide plate 0.5mm. in thickness to fall upon a photographic plate (Fig. 3). The

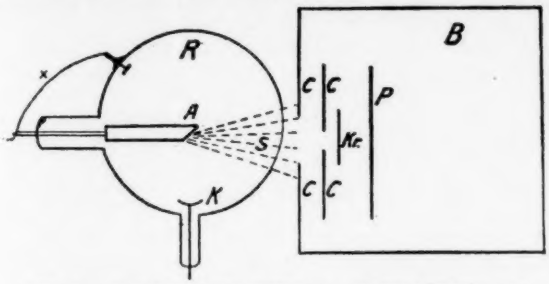


FIG. 3. R, ROENTGEN TUBE; A, ANTICATHODE; K, CATHODE; C C, LEAD SCREENS; B, LEAD BOX; Kr, CRYSTAL OF ZINC SULPHIDE; P, PHOTOGRAPHIC PLATE; S, X-RAYS

result corresponded exactly to the theory (Fig. 4), thus the experiment not only completely confirmed the theory, thereby furnishing direct proof of the wave nature of X-rays, but at the same time furnished a proof of the hitherto purely hypothetical concept of the internal construction of crystals. The great practical importance of this experiment consists

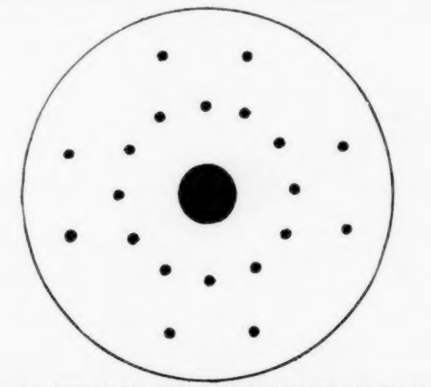


FIG. 4. DIAGRAM OF ATOM PHOTOGRAM AFTER LAUE, FRIEDRICH AND KNIPPING

chiefly in the fact that it provides us for the first time with means of measuring the wave length of X-rays. The results obtained practically coincide with the previously estimated magnitude of 0.01 microns.

AGGLUTINATING SOLID POWDERS BY COMPARISON

It has been known for a number of years that it is possible to agglutinate certain powdered solids by means of compression. The question is not only one of great scientific interest from the light it throws upon certain problems in terrestrial physics, but is also of great importance from a practical point of view, as for example, in preparing tablets or lozenges of certain drugs, or in forming briquettes of various industrial substances. The matter was made the subject of extensive study some twenty years ago by Mr. W. Spring, especially with regard to the plasticity of solid bodies and its relation to the formation of rocks. Quite recently as we learn from the *Zeitschrift für Elektrochemie* (Berlin) of December 1st, 1919, Mr. T. von Hagen of the Physico-Chemical Institute of the University of Berlin, has continued these researches.

Mr. von Hagen's experiments were performed upon more than a hundred pure inorganic substances, including sulphates, oxides, sulphides, nitrates, carbonates, and halogenides. These were reduced to a powder fine enough to pass through a sieve having 25 meshes to the square millimeter. They were compressed into cylindrical tablets weighing about 0.15 gr. each by means of a press capable of exerting a pressure of 500 kg. per square centimeter.

The tablets thus obtained are distinguished by their aspect into five classes as follows:

1. *Plastic Substances.*—Substances so plastic that while being compressed they run over the edges of the press; these bend under the slightest pressure.

2. *Homogeneous tablets.*—These are substances which behave under pressure like semi-liquids and form, consequently, a solid homogeneous mass; these tablets can be cut with a knife and exhibit a plane section; they do not disaggregate under a maximum load of 230 kg. per square centimeter.

3. *Smooth tablets.*—These are substances whose external surface alone assumes a smooth, sleek aspect, but which internally exhibit the form of a pulverulent conglomerate: in the majority of cases these require a pressure of more than 50 kg. per sq. cm. in order to disaggregate them.

4. *Pulverulent tablets.*—These are substances whose external aspect shows no perceptible modification after compression; most of them require a considerable degree of pressure to be disaggregated, but this pressure is less than 50 kg. per sq. cm.

5. *Non-agglutinable substances.*—These are substances which cannot be agglomerated by compression.

Comparison of the various tablets obtained showed that their solidity and aspect depends upon a certain number of properties residing in the original substance.

1. Substances which are related to each other chemically and also with respect to their crystalline character have a similar aspect and an equal degree of hardness when compressed.

2. The fusion point of the substance exerts an influence upon its agglutinability—the higher the fusion point the less agglutinable is the substance.

3. The agglutinability diminishes rapidly in proportion as the degree of hardness augments. Substances of hardness of from 1.0 to 1.5 on the Mohs scale yield "plastic" bodies; those having a hardness of from 1.5 to 2.5 yield "homogeneous," "smooth," or "pulverulent" tablets. When the degree of hardness exceeds 2.5 the agglutinability rapidly diminishes and ceases entirely above the point 5.

4. Von Hagen's results entirely conform with those obtained by Spring with respect to the influence of the moisture adhering to the substances. The quantity of water contained in the constitution of the substances appear to exert no regular influence upon the agglutinability.

5. The solidity of the pulverulent and smooth tablets depends upon the fineness of the grain, increasing as the grain becomes finer.

6. The addition of readily agglutinable substances augments the solidity of tablets composed of substances which are but slightly agglutinable; but the agglutinability of the mixtures is not an additive property of the components: in other words the curve of solidity of tablets composed of two substances in variable percentages is not a linear curve but it is either convex or concave towards the axis of the abscissæ.

Mr. von Hagen subsequently prepared tablets having a definite grain under a pressure ranging from 560 kg. to 9,800 kg. per sq. cm., the tablets having a weight of 0.5 gr. each. When these were compared with respect to hardness, densify, and aspect, it became manifest that these three properties are functions of the pressure. In the case of smooth and pulverulent tablets the density increases with the pressure linearly until it attains almost the same density as the normal substances. Sometimes the tablets assume a homogeneous aspect; the curve of the density then becomes strongly incurved and continues in a direction almost parallel to the

axis of the abscissæ. The aspect of the hardness ceases to vary as soon as the homogeneous condition is attained.

In the endeavor to explain the nature of the quality of agglutinability the investigator was led by his experiments to attribute it to the property of crystals known as plasticity, there being a very close parallelism between the two properties. The more plastic a body is, i.e., the more highly endowed it is with the property of undergoing translations, the less agglutinable it is under pressure. The homogeneous condition is produced by the rearrangement without empty spaces of isolated crystals; this conclusion is confirmed by the microscopic examination of thin sections of the tablets.

NEW UNITS IN THE METRIC SYSTEM—LEGALLY ADOPTED IN FRANCE

THE metric system as at present employed by scientists everywhere and in industry and commerce also on the continent of Europe is frequently called the C.G.S. system from the units of length, mass, and time, upon which it is based, namely, the centimeter, the gram, and the second. These units are so small for industrial purposes that numerous international conferences have recommended the extension of the metric system and a choice of units corresponding to the requirements of industry.

In accordance with this a law was passed in France April 2, 1919, prescribing new units of measurements. This law was published in the form of a decree in the *Journal Official* of Aug. 5, 1919, to take effect one year after.

The units of measurements have been divided into two groups, namely, the principal units and the secondary units:

1. *Principal Units.*—These include those units which it appears probable will never require alteration, i.e., the units of length, of mass, of time, of electric resistance, of intensity, of current, of the interval of temperature, and of the interval of luminous intensity.

2. *Secondary Units.*—These are those units which may require modification as a result of scientific progress.

The principal units in the new system are the meter, the ton, and the second; hence the system is commonly referred to as the M.T.S. system.

Space fobids us to publish minute details of these units, which would in fact be quite unnecessary, but we give below a list of some of the more unfamiliar terms more or less recently adopted.

Kilojoule, the unit of work, equals the work done by one *sthene* whose point of application moves a distance of one meter in the direction of the force, abb. *kj.*

In the C. G. S. the unit of work is the *erg*: this is the work done by a force of one *dyne* whose point of application moves one centimeter in the direction of the force. Since this unit was found to be extremely small in practise the more practical unit of the *joule,* which equals 10^7 *ergs* was adopted. *Megajoule* equals 1,000 *kilojoules,* abb. *mj.*

Sthene, abb. sn., the unit of force, equals the force which in one second of time communicates to a mass equal to one ton, an increase of velocity of one meter per second.

Pieze, abb. *pz.,* the unit of pressure, equals the uniform pressure required to produce a total strain of one *sthene* when distributed over a surface of one square meter. *Myriapieze* equals 10^4 piezes, abb. *mapz.*

Coulomb, the unit of quantity of electricity, equals the quantity of electricity transported during one second of time by an invariable current of one ampere. The *coulomb* is legally represented by the *international coulomb* which corresponds to the electrolytic deposit of 0.001118 gr. of silver.

The *ampere-hour* equals 3,600 *coulombs* and represents the quantity of electricity transported in one hour by a current of one ampere.

Barye, the unit of pressure in the C.G.S. system equals the pressure which corresponds to one *dyne* per square centimeter: The *pieze* equals 10^4 *baryes.*

Dioptrie, the unit of power in the M.T.S. optical system, equals the power of an optical system whose focal distance equals one meter.

Phot, the unit of illumination in the M.T.S. system equals 10^4 *lux.*

Poncelet, a unit of power equals 100 kilogram meters per second or 981 *watts* per second.

Lumen, the unit of luminous *flux,* equals the emanation from a uniform source of infinitely small dimensions and of an intensity equal to 1. bougie (candle-power) and radiated in one second in the solid angle which cuts off an area equal to one square meter upon a sphere whose radius is one meter and whose center is the luminous source, abb, *lu.*

Lux, equals the illumination of a surface of one square meter receiving a *flux* of one *lumen* uniformly distributed, abb. *lx.*

A NEW TEXTILE FROM THE BARK OF THE "SILKWORM MULBERRY"

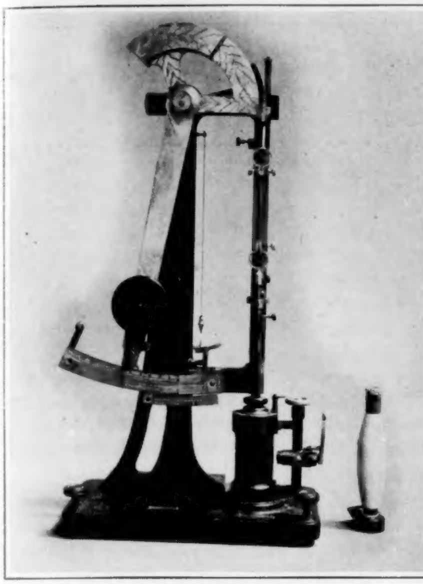
THE earnest efforts instigated by the war to discover fresh materials for the manufacture of textiles, has led to the simultaneous discovery in France and in Italy of a method of manufacturing a textile from the bark of the silkworm mulberry tree. This bark contains fibers which are so long and so fine that they are comparable to those of flax. Efforts have long been made on this account to find some way of utilizing the twigs and bark resulting from the annual clipping of the trees. Mr. Pol Paxion, in France, and Mr. Sansone Antonio, in Italy, have separately devised such a method and the results have attracted great attention, not only in France and Italy but in Japan and Indo-China. In the latter country there are certain dwarf varieties of the mulberry tree which are regularly pruned once or twice per year, and it is estimated that if these twigs were planted in good ground, they would soon reach a height of 1½ meters to 2 meters.

Mr. Antonio retains for his product the name gelso-lino (mulberry flax) employed by the first investigators along this line, some fifty years ago. Both short and long fibers are obtained by this new process. It is stated that the long fibers can be used for making cloth either alone or mixed with wool or cotton. These fibers are said to be very strong. The short fiber will probably be employed in paper making as a substitute for pulp made from rags. The yield of blanched fibers amounts to from 10 to 20 per cent of the dry bark, or 2 to 5 per cent of the weight of the branches treated.

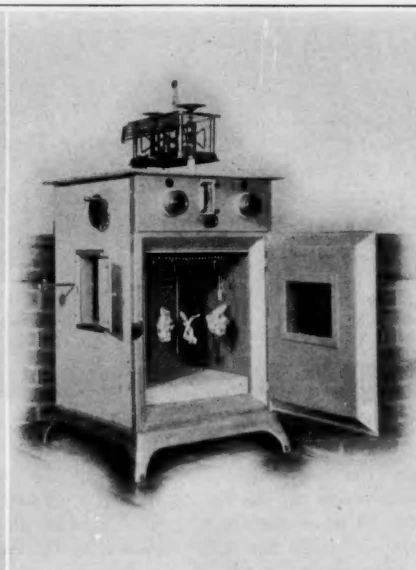
DETERMINING THE VALUE OF A SILK FABRIC

THE amount of finish of a silk fabric may be ascertained by drying a sample until constant, soaking for 24 hours in a 3 per cent solution of sodium carbonate, washing, boiling for half-an-hour in 3 per cent hydrochloric acid, squeezing, washing, pressing between blotting paper and drying till constant, the loss in weight being regarded as finish.

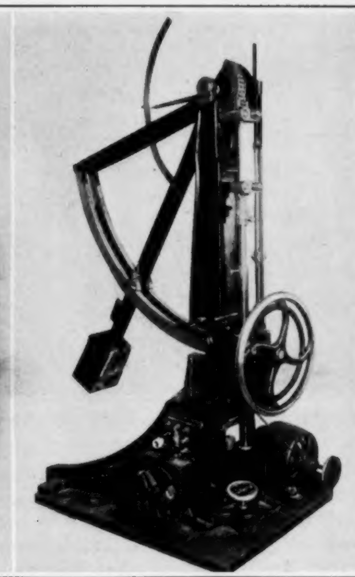
To determine the fastness of the color, a small sample is rubbed on rough white paper or muslin, the resulting stain being noted. Another sample is fixed on cardboard and exposed to light for several days, part being masked, and the mask moved a little when fading commences, this being repeated several times. In a wet method the samples are soaked for 24 hours in 10 times their own weight of cold water, and the amount of extraction or loss of color noted. Samples are also boiled five minutes in Marseilles soap sodium (1 oz. per quart). Vegetable fibers in white fabrics are revealed by the negative result of immersion in a hot, slightly acid bath of xylidine scarlet, and wool by the brown coloration obtained on boiling in sodium plumbate. Natural or gelatine silk heated over a Bunsen flame will smell like burnt horn, and the fumes will turn red litmus paper blue. Little or no smell and the converse reaction with litmus indicate cellulose silk. Gelatine silk is stained brownish-red, and natural silk yellow, on immersion in iodine dissolved in potassium iodide.—*Posselt's Textile Journal; Textile Manufacturer,* April 15, 1910. Abstracted by *The Technical Review.*



TENSION APPARATUS FOR TESTING THE STRENGTH OF YARN



MOISTURE DETERMINING APPARATUS. NOTE THE TORSION BALANCE



ELECTRICALLY-DRIVEN APPARATUS FOR TESTING STRAIN

Textile Research Laboratory

Miniature Textile Mill of the National Bureau of Standards

By Herbert T. Wade

AT the National Bureau of Standards at Washington, the recently completed Industrial Building houses many important activities, but none is more interesting and significant than the work in textile research. This has been under way for several years with marked success, and in its present quarters, some views of which are presented herewith, is capable of expansion as means and facilities are provided. All of this work, as will appear, is very practical, and the Industrial Building, in the ground floor and basement of which are located the textile laboratories, closely resembles a modern factory building of most approved type built of reinforced concrete with abundance of glass sash to afford ample light. The building is practical in every respect, being neither academic nor official in appearance.

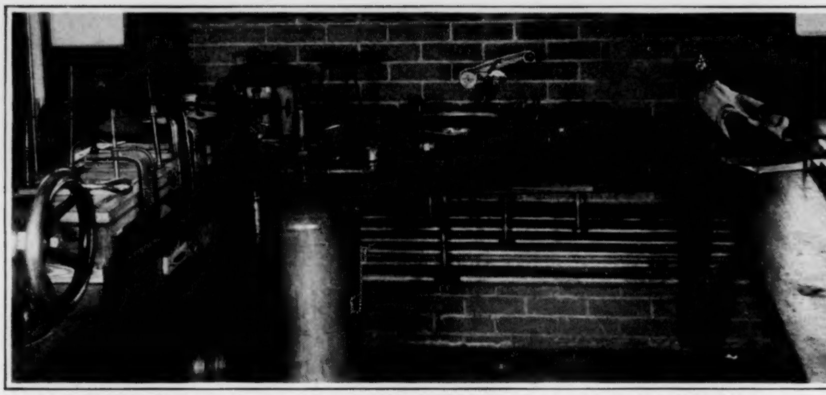
The work here carried on is commercial research, interesting as distinguished from the scientific and pure research in physics, chemistry, and engineering performed in other departments of the Bureau of Standards and in various technical laboratories. Possibly a leading characteristic of such commercial research is that its prosecutors start at the outset with an idea of what the results are to be and seek to find the practical way in which these results can be obtained for commercial application.

While standards of material and products are investigated and determined, attention is none the less given to methods of production with the aim that these too can be improved upon and standardized. First perhaps in such a general process is the development or improvement of proper test methods, and once these are correct and uniform, it is only a matter of time when they become standard for an industry and uniform throughout the country. Such test methods naturally control both raw materials and finished products and result in standards and uniformity for both.

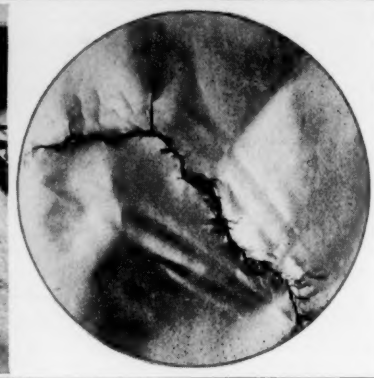
Accordingly at the Textile Branch of the Bureau of Standards the first work in importance is concerned with correct testing methods. For textiles and their constituent fibers and yarns such properties as weight, tensile and breaking strength, elasticity, and other physical properties must be determined, for these naturally control the quality of the raw or unfinished material as well as that of the finished product into which it enters. Consequently various methods are employed to determine these physical properties, and their daily determination is a routine matter in many mill and commercial laboratories. It is, however, necessary and desirable to establish uniform conditions of test particularly in case of fibers and fabrics where temperature and moisture are well known to exert important effects. Accordingly at the Bureau of Standards as a fundamental requisite all tests and test conditions are reduced to a standard humidity and temperature for convenience called normal atmosphere. There has been selected as standard a relative humidity of 65 per cent and a temperature of 70 degrees Fahrenheit. This condition actually is realized and maintained in the testing laboratory by a system of automatic control and appropriate thermostats and dehumidifying and moistening mechanism. This state is a mean or average which in practice is easy to secure in a mill laboratory. In the laboratory in addition to temperature and humidity control the air is changed every six minutes through a circulation and ventilation system. There are double doors, and as the main laboratory is in the center of the building there are no outside walls. The walls are of six-inch tile, plastered on both sides and with such a finish as to prevent atmospheric condensation on their surface.

In this laboratory are installed various testing machines of different types and for different objects, and here they are used under standard conditions. Many are of American manufacture representing those constantly used in mills and commercial laboratories, others are of foreign design and construction, while others represent the efforts of the physicists of the Bureau of Standards to improve on existing practice or to supply a special need by a newly or specially developed instrument or device.

In this connection it may be stated, what is probably well known to most of our readers, that all fibers absorb moisture. Vegetable fibers increase in weight and strength with moisture, while animal fibers also increase in weight, but



BURSTING APPARATUS USED TO TEST THE STRENGTH OF BALLOON FABRICS

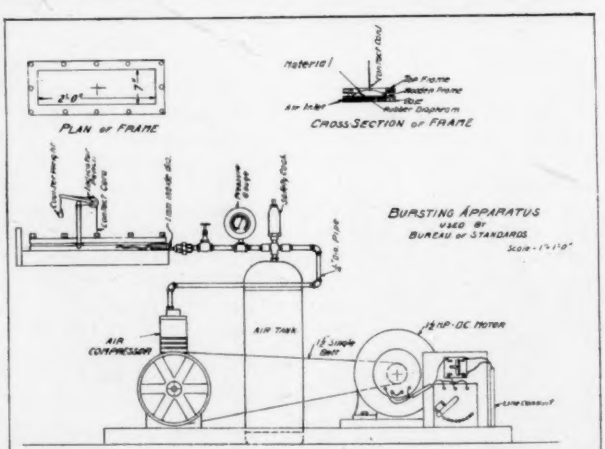


BALLOON FABRIC AFTER TEST

show decreased strength. Accordingly the importance of standard conditions and standard specifications can be realized, as these must be secured in order to make tests comparable. The strength machines, several of which are illustrated, are of various types and capacities with a range of from ½ gram for fibers to 1,000 kilograms for a cloth specimen. They are for the most part inclination balances where the tension is gradually increased hydraulically or by operation of an electric motor until rupture takes place, when the appropriate amount is read off at the indicator which is duly arrested at this point.

In many of these machines from commercial practice the anomalies of American and British usage in employing a double system of units are evident. The strain may be measured in kilograms and the length or breadth of the test specimen of fiber or fabric in inches. It is hoped in this connection that all such tests eventually may be on a single international and preferably the metric system.

In this laboratory are to be seen machines of similar types from different makers as well as those of different patterns submitted by the manufacturers of testing machinery for systematic use and criticism. In this way the makers are able to embody in their designs improvements suggested by the experience of the Bureau's physicists. Not only in textile instruments but in other apparatus, it may be said that the work of progressive and pioneer instrument makers in coöperation with the Bureau of Standards has resulted in so raising the standard of the American products that the United States today in a large measure is practically independent of foreign scientific instruments of precision.



DETAILS OF THE BURSTING APPARATUS

Returning to textile testing, the next element is weight and as has been stated this depends partly upon the moisture content. To determine this, it is necessary to dry the sample in a drying oven with temperature controlled by thermostats. In the special type used and here illustrated, the weighing can be done while the fiber or yarn is in the oven which is maintained at the specified temperature, by means of a torsion balance placed above, with a system of hooks for transferring the baskets containing the fiber or yarn to the scale pan. Naturally there are various types of these ovens as they figure in commercial testing to a large degree.

Reeling and measuring machines, steel dies for cutting out standard size test samples of fabrics for accurate weighing to determine the weight per yard, micrometer devices for measuring thickness of fabrics and also resiliency in the case of felt, for example that used on piano hammers, all are of approved commercial practice but always the best, and it is the aim of the laboratory always to seek to be a step ahead and to find superior devices and methods which may be recommended as advantageous to the industry. For instance, in the familiar thread counting device used in the study of woven fabrics, a special illuminating device has been installed and the micrometer so improved as to facilitate the direct reading of the number of threads in a given unit surface.

Naturally in a textile laboratory microscopy plays an important part and both fiber and fabrics are carefully studied and photographed. Magnification brings out characteristics of individual fibers and affords a ready means for their recognition and study. Negatives and prints made with a special photomicrographic apparatus are filed away along with a complete record of the tests and examinations and are invaluable for study and reference. The photomicrographic room and outfit is of interest, as here not only can the microscope slides be photographed, but they can be projected on a large screen and there observed in their enlarged form. This, it may be said in passing, is now a usual and important feature of many industrial laboratories and test rooms where the microscope is used, for the enlarged projected object can be discussed and demonstrated with facility before a group of those interested and thus permits of many new and practical tests. Adjoining the photomicrographic room is a chemical laboratory arranged for the usual textile tests and analyses without any special research features which would be considered necessary in the Bureau's main chemical laboratories. Of course it is realized in testing and similar studies that while the microscope can be used for qualitative determinations in the study of the fibers and various materials in a fabric, the chemical laboratory is necessary to furnish the quantitative information.

An interesting study carried on at the Bureau during the war, and which in its completed form affords a comprehensive record and summary of the entire subject, was the investigation of airplane and balloon fabrics from the allies and

from captured German aircraft. This was of special significance in view of the development work in connection with special airplane and balloon fabrics to be referred to later, but mentioned at this point in view of the completeness of the tests and analyses of all those materials which could be secured for study. A complete investigation was conducted of the entire subject from the nature of the original fibers, to the treatment and use of the finished fabric, including a full record of the various samples, a number of which were from experimental fabrics.

In the case of the balloon fabrics developed at the Bureau, of which the illustrations show some of the tests for gas retention and bursting strength, there was a full study of various samples beginning with the individual fibers under the microscope. Early examinations were made of fine sections sliced off by a microtome to determine among other things the extent to which the rubber proofing had permeated the fabric. After a complete qualitative and quantitative examination for its composition the fabric was submitted to a test for bursting strength as here illustrated. The sample was clamped in a frame and a constantly increasing pressure supplied until rupture took place. Through these studies and tests a very satisfactory balloon fabric was secured for the United States Army and Navy, which unquestionably would have figured in any further construction of dirigible or observation balloons had the war continued, as it was far superior to European samples.

In the development of original tests the aim is to reproduce working or service conditions so far as possible. Thus experimental apparatus for the abrasive test of fabrics seeks to simulate conditions of actual wear. A revolving cylinder coated with an abrasive bears against the fabric under test with specified conditions of pressure and tension, speed of revolution, duration, etc. In this way the resistance of the sample under such conditions can be determined and the relative wearing qualities of several fabrics ascertained. This apparatus, it may be said, is still in an experimental stage and has not been reduced to permanent and standardized form for official tests.

The activities so far described have dealt with testing. Now comes the research work proper on a large scale where various fibers can be treated and turned into finished fabrics on a production scale though naturally on a greatly reduced basis. Here are full sized machines of commercial type, power driven by individual motors, and representing the best standard practice. These can turn out cloth or knit goods affording data for a complete record of raw materials, process and efficiency of individual machines, should this last item be desired. There are in brief miniature cotton and woolen mills where the complete process from fiber to fabric is carried on.

In the space on the first floor devoted to cotton there is a picker room, card room, and general mill. In the last are included the combing, drawing, spinning, and weaving machines, a combination hardly to be found in actual practice, but in this case there is no special objection to such an arrangement as it is not proposed to carry on all the processes at one time simultaneously. In the picker room the bale of cotton is opened and cleaned, passing through an automatic feeder, opener, breaker picker and finisher picker. This work usually is done in three stages, beginning with the breaker, and passing to the intermediate and finisher, the aim being to eliminate sand, broken leaf, and seed dirt, and to produce a lap of uniform thickness and weight, but here the cotton is passed through the breaker picker and then through the finisher picker twice. The lap thus formed passes to the cards, of which there are two machines each of 40 inches in an adjoining room, where in a series of processes most of the dirt, short fibers, and tangled bunches of fiber are removed and a round strand known as a sliver produced. This process, as well as the subsequent combing in the case of fine yarns, is of course adjusted to the kind of yarn or fabric on which the mill is working, the aim being to secure a sliver as free from dirt and of as uniform a staple as it is

THE COTTON MILL, LOOKING TOWARD THE WARPING AND WEAVING PROCESSES

THE COTTON LOOMS AND SPINNING MACHINES—THE CARDING AND OPENING MACHINES IN THE BACKGROUND

mechanically possible. Next there is a continuous drawing process where the card slivers are brought together and are drawn out by drawing rolls. The slivers are drawn several times, first doubled and then drawn, but always straight, however. The drawn sliver then passes into the roving machine where it is twisted as well as further drawn and wound on bobbins. On the last of the roving frames the rovings wound on two bobbins again are twisted, drawn and finally made ready for the spinning frame adapted to the desired kind and size of yarn, these being of the ring spinning type. The drawing and roving machines are to secure a parallelism of the individual fibers and a roving of uniform weight per yard.

To one acquainted with textile manufacturing there is no special novelty either in the processes or in individual machines. Interest, however, attaches to their assembly and use in a small group according to a logical plan and purpose. The machinery here is all commercial with minor or special changes for convenience rather than for quantity production or manufacturing efficiency.

Once the cotton yarn is spun it goes to the warp frame to be beamed and sized, the latter process being performed in a slasher. The filling yarn can be woven as soon as it comes from the spinning frame. The sizing process is to glue the fuzzy fibers into the yarn and to give it a glazed surface to reduce friction in weaving. On looms which are both plain and fancy, fabrics are woven from the yarns in the usual way. There are also knitting frames for making socks which can use any desired or special yarns.

Throughout the laboratories there is an improved humidification system which can be set to maintain within reasonable limits the degree of relative humidity required for the mill atmosphere. The humidifier, refrigerator, and pump are located below in the basement and all operate automatically.

In the wool and worsted department the same general processes are followed as with cotton, though here the machines in all cases are not of commercial size. There is the wool duster, two sets of cards, one 24-spindle mule, a shoddy picker or machine for reclaiming manufactured wool, that is using old fabrics to furnish fibers, reworking them into shoddy, which in many cases is more desirable and efficient than virgin wool, also a shear, a press, two felting stocks, hardener, steam table, etc., and a fulling mill.

The wool is duly carded, drawn, etc., and the process followed with the rovings spun into yarn by a mule as shown in the illustration, which except for its reduced extent is the same as would be seen in a regular woolen mill. There are also the looms on which the cloth is woven.

It must be borne in mind that this is a laboratory and not a textile mill designed for commercial manufacturing. Here production, even when it can be secured on a practical scale is only an incident, as the aim is to determine the possibilities of various ideas and methods which if successful can be carried out on a large scale in actual practice. For example, by using reworked wool or various mixtures of cotton and wool, fabrics can be made experimentally whose physical properties can be studied.

The composition of the most satisfactory army blanket was one of the studies made at the Bureau of Standards and the most efficient and economical combination of raw material was determined. In any case a certain number of yards of an experimental fabric can be woven and submitted to various tests to prove or disprove the correctness of the underlying hypotheses on which the work was projected. The sizing of the yarn might be varied, tension or other conditions adjusted and the effects on the resulting product determined.

The textile industry in the United States is becoming constantly more technical and exact, and rule of thumb methods based on limited mill experience are giving way to expert training and technical processes. Consequently work done at the Bureau of Standards aims to help in the general problems of the industry as well as certain direct and often routine problems or tests of the Government.

These Government problems of course vary from time to time, but the recent war brought a number to the fore and their successful solution at the Bureau of Standards more than vindicated the wisdom of establishing the Textile Branch. Foremost perhaps of these was the development of a satisfactory cotton airplane cloth, undertaken and brought to a satisfactory conclusion by Mr. E. D. Walen, then in charge of this branch. Anticipating the possible shortage of linen and the need for aircraft fabric as early as 1916 Mr. Walen

began the systematic study of the linen then used for aircraft in order to determine its general and also the peculiar property which made it suitable for this purpose. The Bureau investigated the linen fabric as a structural material, determined its essential characteristics for this application, and then sought to realize and duplicate these necessary properties in a cotton fabric, securing equal strength and even higher resistance. As a result of this purely textile investigation vast quantities of the new fabric were manufactured and used, even the British making large purchases which they employed in preference to linen at the end of the war.

In the manufacture of gas masks the Bureau of Standards in coöperation with the Chemical War Service of the United States Army and the manufacturers, developed a felt which would exclude the so-called solid gases. The perfection of a balloon fabric for the United States Army already has been mentioned. A work of peace has been the development of an improved prison uniform cloth that for comfort and service has been found most durable and satisfactory. By determining and grading the surplus textile products offered for sale by the United States War Department there resulted to the Government a considerable profit as various classes of goods could be sold separately by grade and thus bring higher prices.

While the Bureau is always busy with its tests and in formulating specifications for the needs and purchases of the different department of the Government, it is ready always to coöperate with manufacturers in straight production problems and development work. It naturally aims to develop standards of products as the needs of the industry require. The Bureau does not do for private corporations or individuals routine or commercial testing which is effectively carried on in commercial laboratories. Through its present development and standardization work the Bureau has been able to accomplish a great deal for American industry, and textile manufacturers are appreciating its facilities and efforts more than ever before.

SILK FROM SPIDERS

It is in the tropics that the raising of spiders for the sake of their silk is most feasible. A Spanish traveler of the seventeenth century, Don Felix d'Azara, described garments made by the Indians of Paraguay with the silk produced by the *Epeiras socialis*. Various silk spinning spiders are found likewise in China, India and West Africa. A specially desirable species, according to a writer in *La Revue Scientifique* (Paris) of April 24, 1920, is the "*Halabé*" of Madagascar. This is unusually large, the female (which is the sole spinner) attaining a length of 7 cm. and producing a considerable quantity of very beautiful silk of a rich golden yellow. While this silk is very fine it is much stronger than that of the silk worm. It possesses the great advantage of not needing to be carded or spun. It is ready to be woven just as it comes from the spinnerets of the animal. The yellow color is readily removed by bleaching. There are said to be millions of these creatures in the wooded areas of Madagascar, especially near Tananarive. They are in fact an article of commerce among the natives, selling for 40 centimes per hundred.

They are sedentary in habit and make no attempt to escape from the enclosures or yards where they are kept. It is only necessary to erect bamboo rods, three meters in length, in lines spaced 50 cm. apart so that they can spin their webs.

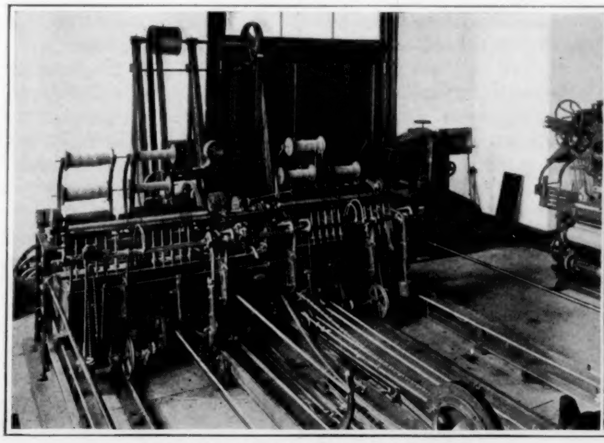
An ingenious method is used to increase the yield of silk, borrowed from a nineteenth century English silk spinner named Rolt, who conceived the idea of reeling the silk directly as it issued from the spinnerets. By operating in this manner with the European species *Epeira Diadema* Rolt succeeded in obtaining in 12 hours from 22 spiders a thread no less than 6 kilometers long! This method has been applied to the *halabes* by M. Caboué of Madagascar, who has thus obtained some very beautiful specimens of silk with a very primitive sort of apparatus. An improvement in the method was effected by M. Nogué, sub-director of the Professional School of Tananarive, to the end of obtaining a more regular production. He has constructed a machine serving for the simultaneous reeling of the silk from a dozen spiders and the twisting of the fibers from the spinnerets. The thread thus obtained is double, so that it contains practically 24 fibers instead of 12.

Each *halabé* produces 300 to 400 meters of silk at each reeling and is capable of being reeled 4 or 5 times at intervals of 10 days before dying.

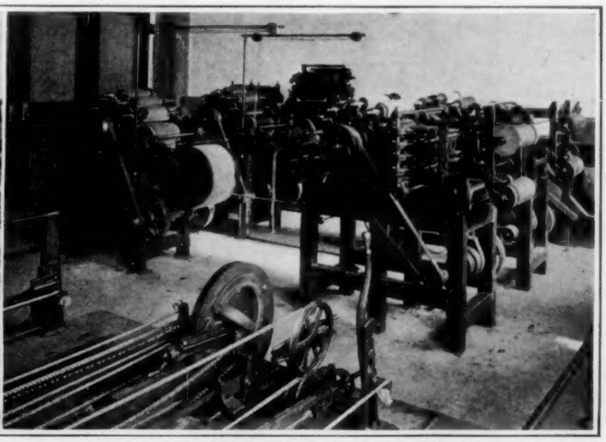
Since the spiders are carnivorous, living on insects which they catch themselves, it is presumably much cheaper to rear them than to breed silk worms. Apparently we have here the beginning of a promising industry, at least in the tropics. While the silk of the *Epeira Diadema* was actually used in an 18th century experiment for making a fabric as well as for stockings and mittens, the difficulties involved and the frailness of the textiles produced have prevented the matter from being followed up. The silk of this European species, however, is used in optical instruments because of its extreme fineness, a filament being about one-ninetieth as large as that of the silk worm.

PROTECTING MILITARY CLOTHING FROM GASES

In the *Revue Textiles et des Arts Industriels* (April 10, 1920) the effect of exposure of military clothing to powder and gases is discussed. An alkaline reaction takes place. The destructive effect of the exposure may be retarded by the use of various acid salts, but chromium salts are the most effective.



A TWENTY-FOUR SPINDLE WOOL MULE



MINIATURE WOOL CARDS AND CONDENSERS

Lubrication in Power Plants*

Some Practical Tests Which May Be Used to Determine the Fitness of Lubricants

By Robert June

An accurate knowledge of lubricants and lubrication on the part of operators and engineers is of vital importance to the economical operation of the power plant. This is true because, even in a plant where the lubricants used are the best adapted for each particular service, the losses of power due to friction may range from 50 to 30 per cent. With improper lubricants the losses due to friction may run much higher, and to these losses may be added the losses in depreciation of equipment caused by wear on bearings, guides, cylinders, etc.

As a general proposition, losses due to friction will be found to vary from 8 per cent in central stations, where energy is produced but not utilized, to 25 per cent in plants such as iron and steel mills, where manufacturing processes are carried on. Reducing this friction power loss by 10 per cent will generally pay for all lubricants used in the course of a year. Hence, the proposition of saving oil does not cause so much concern as does the problem of saving power, for by saving power the cost of lubricants may be offset several times over. This is an aspect of the problem of lubrication that is, unfortunately, not generally appreciated by the plant manager and superintendent or by the operating engineer. Engineers know they get more satisfactory results with certain lubricants than with others, but the value of these results in dollars and cents is almost never placed before them in such a manner that they can fully appreciate their importance.

FRICTION AND LUBRICATION

The function of a lubricant is to reduce friction, which may be defined as the resistance or binding action encountered when one body is drawn over another. Friction will vary with the character of the materials, the smoothness of the surfaces and the pressure exerted to force them together. Fig. 1 illustrates the conditions existing when bodies of different degrees of smoothness are drawn over each other. It is evident that as the roughness of the surfaces increase there is a greater tendency for the projections to lock together, and that greater force will be required to draw the

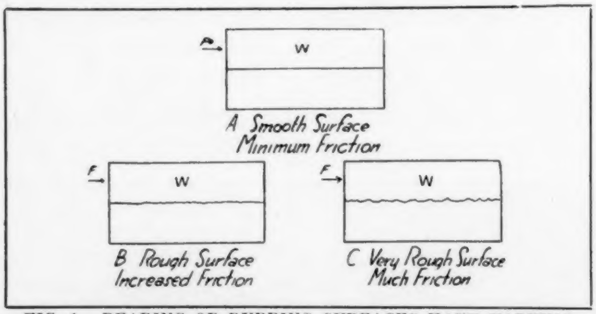


FIG. 1. BEARING OR RUBBING SURFACES HAVE VARYING DEGREES OF SMOOTHNESS

bodies with rougher surfaces over each other than to draw those with smoother surfaces. This clearly shows the importance of giving bearings, guides and cylinders the smoothest possible finish. Unfortunately, we never can obtain complete smoothness of surfaces with any metal and must, therefore, content ourselves with obtaining the smoothest surface possible with the particular materials employed.

The purpose of lubrication is to interpose a film of oil between the moving surfaces, thus forcing them apart so that actual contact of metal with metal is avoided, leaving only the fluid friction of the lubricant. The expression "fluid friction of the lubricant" may be taken as referring to the resistance of the oil to the force tending to pull its particles apart. This can best be understood by referring to Fig. 2, wherein an attempt has been made to show the condition of the lubricant in a bearing in action. It will be seen that the oil which is in closest contact with the shaft moves at a much faster rate than that which is in closest contact with the bearing. In other words, we have what may be termed a number of layers of oil between the shaft and the bearing, each moving at a progressively faster rate, depending upon their proximity to the shaft.

It is this condition of fluid friction set up in the oil which

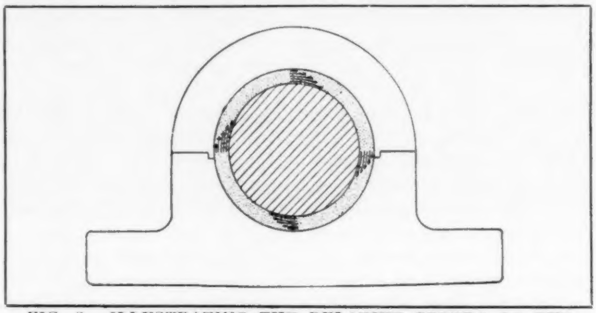


FIG. 2. ILLUSTRATING THE RELATIVE SPEEDS OF THE VARIOUS LAYERS OF OIL SURROUNDING A SHAFT IN A BEARING

makes the choice of a proper lubricant extremely important. The reason for this is that operating conditions vary widely, depending upon the pressure tending to force the bodies together, the temperatures existing at the point at which the lubricant must be used, etc. Obviously no one lubricant can be expected to meet all conditions of services, so the lubricant best adapted for each particular service must be selected.

CHARACTERISTICS OF A GOOD LUBRICANT

A good lubricant is one which, for the particular service under consideration, possesses the following characteristics: It should prevent the surfaces from coming into contact under conditions of maximum pressure, ability to do this being a function of viscosity or, as it is sometimes called, "body" of the oil; it should absorb and carry away heat, have a low coefficient of friction, be of the lowest viscosity consistent with the work required, and free from any tendency to oxidize. Its temperature of vaporization (flash point) should be high, its freezing point low, and it should be free from acids.

Having outlined the qualifications of a good lubricant for any particular service, the characteristics of the various lubricants available should be examined to see the services for which they are adapted. Lubricants may be divided into various classes such as vegetable oils, animal fats, mineral oils, solid lubricants and greases. Each of these classes possesses certain definite characteristics.

Vegetable oils consist principally of linseed, castor, rapeseed, resin, cotton seed oil, etc. These do not, in themselves, possess lubricating properties of any great practical value, since they oxidize at comparatively low temperatures and are apt to become thick and gummy in a short time. These oils are, therefore, of very poor cold test, congealing at a comparatively high temperature, thus making them inconvenient for use in cold weather. The principal use of these oils for lubricating purposes is confined to the compounding of oils for certain services.

*Reprinted from *Electrical Review*, June 19, 1920.

CHARACTERISTICS OF VARIOUS LUBRICANTS

Animal oils in general use are tallow, neats-foot oil, lard, sperm oil, wool grease, fish oils, etc. Individually these oils possess the same objectionable features as vegetable oils and are, therefore, seldom used in a pure state, but are frequently compounded with the mineral oils. The reason for this compounding, when done, is that the compound oils in general have better lubricating qualities than pure mineral oils of the same viscosity or body. In cylinder lubrication, especially in the presence of moisture caused by steam, the addition of 2 to 5 per cent of tallow seems to increase the lubricating effects. When used in these proportions, the bad effects from the decomposition of the tallow, which may set free acids which attack the metal, and the bad effects of gumming or oxidation are not so great as to overbalance the advantage of better lubrication.

Mineral oils have many advantages as lubricants over animal or vegetable oils. They are cheap and, being of non-organic origin, are of a more stable chemical composition, and do not tend so readily to change their condition by becoming rancid, thick or gummy from exposure to the air, and they have no corrosive action on metals. By what is known as fractional distillation, mineral oils can be separated into a great many different grades, from the lightest spindle oils to the dense, heavy cylinder oils. They are of lower cold test and not so liable to spontaneous combustion as the animal fats. They present a wider range of lubricating properties than oils derived from animal or vegetable sources, the thinnest being more fluid than sperm oil and the thickest more viscous than fats and tallows.

Mineral oils may be separated into various groups and classified as distilled, natural and reduced oils. Distilled oils, which are produced by distillation from crude petroleum, are so treated by various processes, in which alkalies and acids are employed, as to appear in the finished product as transparent fluids of extremely stable composition. Natural oils are prepared crude petroleums from which grit, suspended and tarry impurities have been removed. They are usually dark, opaque and rich in lubricating properties. Reduced oils or, as they are sometimes termed, heavy natural oils, are oils from which the lighter hydrocarbons have been evaporated, and from which the tarry residue has been removed by filtration.

USE AND CHARACTERISTICS OF SOLID LUBRICANTS

Mica, soapstone and dry graphite which are the principal solid lubricants are mixed for use with greases or oils. Their principal use is to be found where great weights have to be carried on small areas, and is usually confined to low speeds. The coefficient of friction for solid lubricants is high, and they are, therefore, not particularly economical. Better results can usually be secured by the use of larger bearing surfaces, but, when design does not permit of these larger surfaces, there is a real field open for their use. Under certain conditions of speed, solid lubricants will sustain pressures under which no liquid would work.

Crystalline or flake graphite is dense and compact and is not easily reduced by crushing between the fingers, so that the individual particles maintain their size. Amorphous graphite, under pressure, continues to be reduced in size until the particles are no longer evident to the touch. Flake graphite is the better lubricant because it has good wearing qualities and adheres to metallic surfaces with which it comes in contact. The value of flake graphite as a lubricant lies in its property of filling any irregularities that exist in a bearing surface, thus reducing the roughness and producing a better surface for lubrication with oil or grease. Neither form of graphite is affected by heat.

Graphite is of value as a lubricant for steam-engine cylinders, provided it is used in moderation and not fed in excess. The entire value of graphite as a lubricant is lost if an excessive amount is used. When the valve seats and cylinder walls of an engine are badly cut or scored, the addition of a little graphite (several teaspoonfuls), mixed with the cylinder oil, will greatly aid in smoothing up the surface of the bearings. For steam-engine cylinders using superheated steam, flake graphite is of great value. It aids in filling up the irregularities of the cylinder wall surfaces so that the cylinder oil, which is greatly reduced in viscosity by the high temperatures found in these cylinders, will have the best possible surface conditions to work on.

In order to obtain a clear idea of the value of graphite as a lubricant, the engineer must appreciate the fact that graphite, to be efficient, must identify itself with the metallic surfaces to be lubricated. Its function is to fill up the pores and depressions in the surfaces, giving them a smooth, polished finish. Lubricating oil must then be introduced between the rubbing surfaces so as to produce a film, which will be more efficient in its results because of the reduced frictional resistance that will have to be overcome.

The specific gravity of graphite being 1.81 is greater than that of oil. For this reason it will settle out on standing so that it is not possible permanently to suspend graphite in oil. A mixture of oil and graphite should never be put in an oil cup or sight-feed lubricator, as the graphite will soon clog the feed passages. For use in engine bearings, a mixture of a heaping teaspoonful of graphite to a pint of oil is sufficient. About 4 per cent by weight is the average good practice when mixed with oils and greases, and gives good results when applied at reasonably long periods. Graphite should never be used on bearings supplied with forced or flooded continuous lubrication.

There is a great variety of lubricating greases. Petroleum cup grease consists of lime soaps, mineral greases and resin oils. Soap gives the grease melting-point and body. Greases are excellent lubricants when properly used, but they have a very narrow range of service and should not be called upon to perform the function of lubrication under conditions to which they are not suited. The use of any solidified lubricant places a drag or friction on the bearing in which it is used. The chief advantage of grease as a lubricant lies in its cleanliness, and in its property to stay put. In bearings revolving at a slow speed, where it would be difficult to maintain a film of lubricant, grease may be used to advantage. For crankpin bearings of high-speed engines, grease will give satisfactory results. Due to its adhesiveness, it will maintain a layer of lubricant when the machine is at rest, and thus reduce the starting friction when the machine is placed in operation.

THE TESTING OF LUBRICANTS

While it is possible to lay out quite elaborate specifications for lubricants, covering every type of service, the fact nevertheless remains that these specifications are, after all, only a starting point. After a particular lubricant has been chosen by specification, it remains to test it out under actual working conditions and then to try other lubricants of such a general nature as to lead the engineer to believe that success might attend their use. Only by comparing the performance of a number of lubricants under actual working conditions, can the best lubricant be chosen for the particular service under consideration. The first step, however, is to choose intelligently several lubricants which are to be tested out. In order to do this it may be well to review the tests and specifications used by large consumers in the purchase of lubricants. Chemical, physical and practical tests are made in the complete examination of an oil for a particular service.

CHEMICAL TESTS OF LUBRICATING OILS

To pass the chemical tests of the Navy Department, "all oils should be neutral in reaction, and should not show the presence of moisture, matter insoluble in petroleum ether (hard asphalt), matter insoluble in ether alcohol (soft asphalt),

free sulphur, charring or wax-like constituents, naphthenic acids, sulphonated oils, soap, resin or tarry constituents, the presence of which indicates adulteration or lack of proper refining. Except in oil for engines without forced lubrication, no traces of fixed oils (animal or vegetable fats) should be found.

"In lubricating oil for main engines without forced lubrication, approved fixed oils such as rapeseed, olive, tallow, lard and neats-foot oil may be used. When the foregoing fixed oils are used, they must be well refined with alkalies, unadulterated, containing a minimum of free fatty acids, with no moisture or gummy constituents. Olive oil should not have a high specific gravity. If satisfactory emulsifying results can be obtained with straight mineral oils on engines without forced lubrication, they may be submitted for service test."

While the small plant owners is not usually in a position to have various tests of oils made in his plant, he can have them made by a commercial laboratory at a cost which, in view of the possible savings to be effected, is well worth the time and expense involved. Large plants, of course, often possess laboratories and are in a position to make the tests themselves. The procedure involved in a satisfactory test may be outlined as follows:

Moisture Test.—Wet the walls of one test tube with the oil under investigation and put 3 or 4 cc. of the oil in a second tube and place in a bath of liquid paraffin, which should be brought up to a temperature of 300 deg. F. If the oil contains water, emulsions will form on the walls and foaming and sputtering will be noted.

Sulphur Test.—Take a small piece of metallic sodium the size of the little finger nail and boil it for 30 min. in 50 cc. of the oil in a test tube. At the end of this time add an equal amount of water and again place over the burner flame until the sodium is dissolved. After the sodium has disappeared, pour off the water and pour in a 1 per cent solution of sodium nitroprusside. If the mixture turns to a violet color the oil contains sulphur.

Tests for Acids and Alkalies.—Pour 25 cc. of oil and 50 cc. of distilled water into a test tube and divide the mixture into two equal parts. Add methyl-orange to one part to determine the presence of acids and add phenolphthalein to the other part to determine the presence of alkalies. The formation of emulsions indicates the presence of acids or alkalies as the case may be. Acids cause corrosion and should be avoided in all cases.

Tests for Matter Insoluble in Ether.—Place 14 cc. of ether alcohol (eight parts of ether and six parts of alcohol) and 11 cc. of oil in a test tube, shake thoroughly for a minute or two and then allow the mixture to stand for 12 hours. At the end of that time, if there is any precipitation at the bottom of the tube, it will be asphalt. Even a trace of asphalt makes the lubricant undesirable, since it causes scoring of journals and clogging of oil lines.

Tests for Matter Insoluble in High Grade Gasoline.—Filter thoroughly 300 cc. of 86 to 88 Baume gasoline and place it in an absolutely clean and dust-proof glass receptacle. Sprinkle 2 cc. of oil into the gasoline and allow the mixture to stand for 12 hours. If there is any precipitate at the end of that time, it will consist of soft asphalt or carbon particles, and even a slight trace would make the oil extremely undesirable for use.

Test for Tarry or Suspended Matter.—This test is carried out in the same manner as the previous one, using, however, 95 cc. of gasoline and 5 cc. of oil. The receptacle may be examined for the presence of precipitate at the end of an hour.

Test to Determine Mineral or Vegetable Oils.—Take a small piece of metallic sodium and bring it to a boil in 10 cc. of oil. The presence of animal or vegetable oils will be indicated if the mixture become gelatinized or of a semi-solid nature.

Test for Presence of Undesirable Carbon or Hydro-Carbon.—This test is made by simply heating a small quantity of oil to a boil in a test tube and then comparing the color of the heated with that of unheated oil. If there is any discoloration it indicates the presence of undesirable constituents.

Gumming Test.—This test indicates the extent to which the oil has been refined and will, therefore, serve as a guide to indicate the extent to which oil may be expected to oxidize or gum when in use. The test is undoubtedly of great value and should always be made when opportunity is afforded. It consists simply of mixing a small quantity of oil in the test tube with an equal quantity of nitrosulphuric acid. If the oil has been properly refined, no change will be noted, but if the oil has been poorly refined the fact will become evident by the simple separation of material of dark color. This separation is the result of oxidation of tarry matter in the lubricant.

It has been found that the result obtained by the gumming tests compares almost exactly with what is known as the carbon residue test, which is made by distilling the oil to dryness in the test tube. This carbon test has been found of great assistance in choosing a satisfactory cylinder lubricant for gas engines, as the presence of carbon always and invariably means trouble in gas engine cylinders.

Tests which have just been outlined are easily within the range of even the small plant operator, and the writer believes that the investigation of the characteristics of the oils being used is well worth the attention of operators in both large and small plants.

This is particularly true because of the fact that the presence of undesirable matter in the oils mean very heavy costs for repairs to equipment and may even cause a shutdown of the plant at critical moments.

HARDENING OF SCREW-GAGES

A PAPER by the late Mr. W. J. Lineham, read before the Institution of Mechanical Engineers, gives the results of a valuable research carried out at the Goldsmiths' College on the hardening of screw gages under conditions that produce so little distortion in pitch as to render lapping after hardening unnecessary.

Hardening depends on the fact that steel, after sudden quenching, remains in the condition that prevailed at the quenching temperature, and it is found that quenching while crossing a recalescence point produces the least amount of distortion. The author's experiments confirm this as regards the Ar 1 line, which is a more constant temperature than the Ar 2 line for varying carbon percentages, but in no case was there complete freedom from distortion. A cyanide bath, followed by a "Pyromelt" salt bath, was used, and in the first series water-hardening was carried out. The paper describes the precaution taken in preparing and gaging the specimens. Apparently extraordinary results were obtained, but the curves of extension over quenching temperature were found, on super-position, to cross pretty consistently at 700°C. As regards water-hardening, it was established that a temperature of minimum distortion that can be relied on is 700°C. (1,292°F.), that no variation is allowable above 700°C., but that an allowance of 10° below 700°C. is practically permissible. A second part to the paper confirms some of the results with actual screw gages instead of the cylindrical planks used in the first experiments, and investigates the conditions for oil hardening. Finally, the author gives the following conclusions: (1) Hardening screw-gages in oil, after casing in cyanide, can be porformed with less distortion than if water is the quenching medium. (2) The temperature at 717°C. (1,323°F.) is the best heat for oil-quenching. (3) By screwing gages to accurate pitch and to diameter at two-thirds below high limit and one-third above low limit, lapping can be dispensed with. In the course of the paper a very remarkable example of distortion of a disk of mild steel is referred to. This, after about 1,000 heatings and quenchings, had increased its thickness from 0.8 to 2.5 in., with a final increase in volume of 1.5 per cent.—W. J. Lineham, paper read before the Institution of Mechanical Engineers, April 23, 1920, 28 pp. Abstracted by *The Technical Review.*

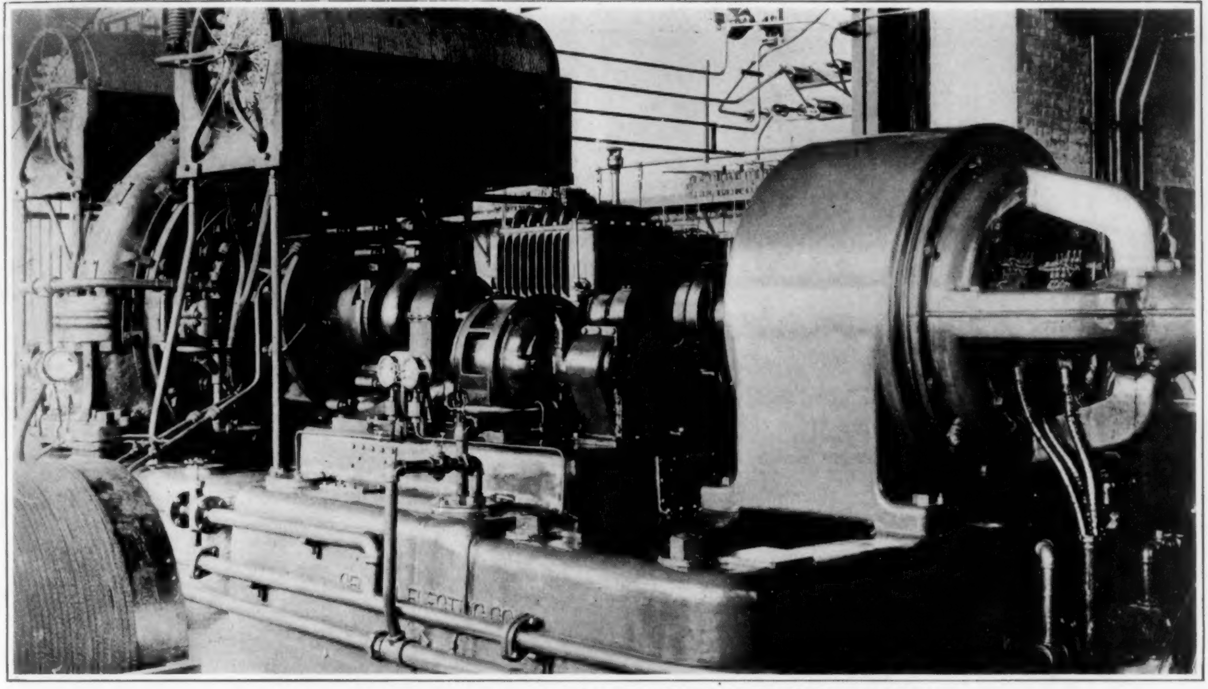


FIG. 1. MOTOR END VIEW OF A 200-KILOWATT ALEXANDERSON MOTOR

High Power Continuous Wave Radio Apparatus

The Alexanderson System for Radio-Telegraph and Radio-Telephone Transmission

Abstracted from a paper by Elmer E. Bucher

RADIO engineers early foresaw that the ultimate generator of oscillations for radio-telegraphy and telephony would be one of a type providing more efficient and reliable operation than the systems utilizing the "arc" and "spark." In fact the literature of the past makes frequent references to the desirability of an oscillation generator constructed along the lines of an ordinary power-house alternator; but because such alternators were required to provide frequencies a thousand times or more in excess of those used in power engineering, new problems of designs were encountered which were declared by many to be well-nigh insurmountable. For a time the development of the art seemed to follow the line of least resistance, and it resulted in the evolution of several systems utilizing the "arc," the "spark gap," and the type of radio frequency alternator which generates at a comparatively low frequency, the necessary increase of frequency being obtained either by groups of mono-inductive transformers external to the alternator, or by tuned "reflector" circuits associated with the alternator. None of these systems, however, can be said to have satisfied fully the exacting requirements of commercial operation.

An oscillation generator suitable for commercial radio service over great distances should possess the following qualifications:

(1) It should generate a steady stream of oscillations of constant amplitude.

(2) It should generate a so-called "pure" wave; that is, a fundamental wave in which the radiation incurred by super-imposed harmonics is negligible.

(3) It should provide a performance as reliable as the ordinary power dynamo.

(4) It should operate economically and efficiently.

(5) It should permit manufacture of units in any desired power.

(6) The design of the whole system should be such as to permit telegraphic signaling at very high speeds.

For a number of years the design of radio frequency alternators has occupied the attention of Mr. Ernst F. W. Alexanderson and his staff. Starting with the development of several experimental types of alternators, they have steadily progressed toward the designs of more powerful machines which are now available for commercial use. Standardized alternator sets for transmission at wave lengths between 6,000 and 10,000 meters and between 10,500 and 25,000 meters, are now in production. This description is devoted principally to the discussion of a 200-kilowatt set, although sets of other powers are now under construction.

In September, 1918, a 200-kilowatt alternator set was installed at the New Brunswick (N. J.) station of the Radio Corporation, and from that time it has provided continuous and most satisfactory service in continent-to-continent communication. Normal transmission is at present conducted at the wave length of 13,600 meters, with antenna current of 400 amperes corresponding to an alternator output of approximately 80 kilowatts. With this fractional value of the available output of the alternator, transoceanic communication has been maintained with European stations throughout the twenty-four hours of the day. The alternator is capable of supplying 600 amperes to the New Brunswick antenna, but its full output of 200 kilowatts is not at present utilized, owing to the lack of adequate power supply at that point. The alternator, as installed at the New Brunswick station, is shown in Fig. 1. It is capable of producing any wave length from 10,500 to 25,000 meters. Lower frequencies can be obtained by running the alternator at reduced speed.

A high power radio station of the Alexanderson type contains three important developments:

(1) An alternator—which generates currents *directly* at the

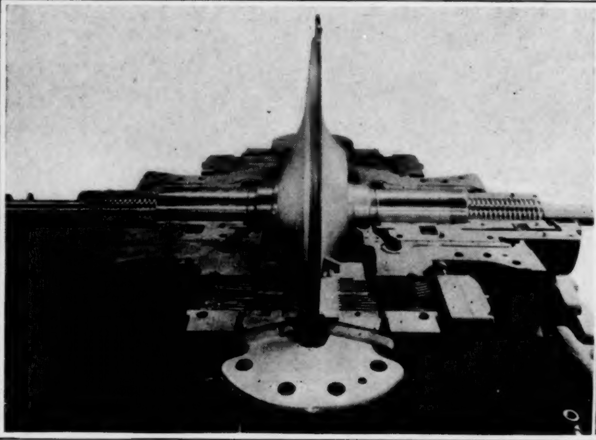


FIG. 2. ALTERNATOR WITH TOP HALF REMOVED

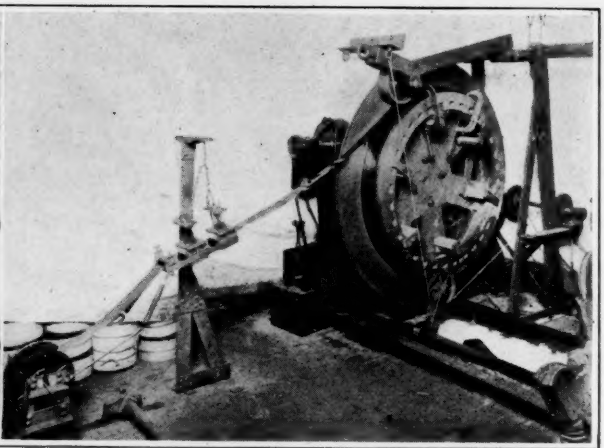


FIG. 3. METHOD OF ASSEMBLING THE ARMATURE

frequencies which are required for the radio circuits with which it is associated. The frequency of these currents is solely dependent upon the number of field poles on the machine, and upon the speed at which the rotating member is driven. This is in distinct contrast to certain other systems in which the radio frequency currents are obtained *indirectly* by means of "reflector circuits" or frequency raising transformers electrically associated with the alternator.

(2) A magnetic amplifier—which provides a non-arcing control of the alternator output for radio telegraphy, and is equally applicable to radio telephony.

(3) A multiple tuned antenna—a development which has markedly reduced the wasteful resistance of the flat-top antenna, and has therefore increased the transmitter overall efficiency many fold.

The alternator is an *inductor type* of generator with a solid steel rotor having several hundred slots milled radially on each side of the rim. The slots are filled in with non-magnetic material, with the object of reducing wind friction to a minimum. The fillers are brazed into the disk in order that they may withstand the centrifugal strain of rotation. The rotor is designed for maximum mechanical strength by providing it with a thin rim and a much thicker hub. With this construction the strain on the material due to centrifugal force is the same from the shaft to the outer rim.

The *rotor* of the 200-kw. alternator (with half of the field frame removed) is shown in Fig. 2. This also shows the collars of the thrust bearings and a partial sectional view of the main bearing housings.

An assembled 200-kw. alternator with its driving motor is shown in Fig. 3. The alternator is driven by a 600-hp. induction motor of the wound-rotor type, which is operated from a 60-cycle, 2,300 volt, quarter-phase source of supply. The motor is connected to the alternator through a double helical gear (with a speed step-up ratio of 1:2.97), which operates in a container partially filled with oil.

The *main bearings* and the *thrust bearings* of the alternator are oil-lubricated by force feed at pressures varying from 5 to 15 pounds according to the demand on the bearing. During the periods of stopping and starting, and in possible emergencies, oil is supplied by a special *motor-driven pump* mounted on the alternator base. When the alternator is working under normal operating conditions, a *separate pump* geared to the main driving shaft feeds the bearings, and the *motor-driven pump* is automatically cut out of service. The *oil-supply tank* is located in the base of the alternator, to which the oil returns after being pumped through the bearings. The oil gage on the main feed pipe is fitted with a *signaling circuit* to call the attention of the operator in case the oil supply fails. The main bearings of the alternator, which are self-aligning, are also *water-cooled* by a series of copper pipes which run through the bearings near to the friction surface. The armatures of the alternator are also water-cooled from the same pumping source by a series of parallel copper tubes cemented in the frame alongside the laminations.

In order to avoid large losses through magnetic leakage, the air gap between the rotor and the stator frame is maintained at a spacing of 1 millimeter. It is important that the rotor be kept accurately centered, for otherwise the armature coils on one side of the rotor will become overloaded. This is accomplished by the use of specially designed *thrust bearings* which are inter-connected by a set of *equalizing levers* with an adjustable controlling leaf between them. These prevent the possibility of binding between the thrusts, due to expansion of the shaft from heating, and they also take up automatically all slack in the bearings as they become worn. Any tendency toward a change in the air gap is thus counteracted by the action of the levers. The equalizers are in part, the heavy vertical column shown at the end of the alternator in Fig. 4. Should the air gap on either side tend to get smaller, the pull of the field on that side would cause an excessive strain on the thrust at that end and cause heating. This, however, is prevented by the leverage system, which automatically corrects this and holds the rotor in a central position at all times.

In regard to some of the electrical features of the alternator it will be noted from Fig. 5 that the *armature* and *field coils* are stationary, the requisite flux variations for the generation of radio frequency currents being obtained from the slots cut in the rotor. The diagram points out the fundamental construction of the alternator and the general mode of winding the armature. The rotor disk revolves between the two faces of the field yokes. The direct current supplied to the field coils produces a magnetic field flux which passes between the field yoke faces and through the rotor as shown by the arrows.

The armature coils, which are placed in slots cut in the two faces of the field frames, are shown in the sketch as tipped away from the rotor, although in the actual machine the spacing between the rotor and the frame is but 1 millimeter. Two distinct armature windings are thus provided, one on each side of the rotor. There is but one conductor in each slot and two of these slots make a complete loop, and comprise a *pole* in the armature windings. One slot in the rotor is therefore provided for each loop in the winding. The armature windings on each side of the rotor are divided into thirty-two independent sections, the circuits of which are completed through *transformer primary coils* as shown in Fig. 5. Each primary consists of two turns with sixteen separate wires in each turn. There is no direct connection between the individual armature sections, but through the two-turn primaries, they combine to act upon the secondary coils of the transformers. It is obvious that with this division of armature circuits

the potential on any armature coil (or on the corresponding transformer primary) is very low, and as such, it permits a grounded or open-circuit armature coil to be cut out of the circuit and the operation of the alternator to be continued with but a slight decrease in its output—an obvious advantage.

Fig. 3 shows the laminated armature under assembly, which is wound with 0.037 millimeter steel ribbon and afterward machined into shape.

A transformer is provided for the armature coils on either side of the rotor. There are therefore two transformers, and they each contain the three coils P_1, S_5, S_1 and P_2, S_5, S_2, shown in the fundamental station diagram Fig. 6. The primary of each transformer contains two turns of sixteen wires each, as mentioned above. The *intermediate coils* S_5 have twelve turns on each transformer. The two intermediate coils are connected in parallel, and are shunted by the magnetic amplifier. The coils S_5 are also connected in series with the secondary proper and the antenna system.

The *secondary coils*, which consist of seventy-four turns on each transformer, are wound so that their high potential ends are at the center, in order to provide a uniform potential gradient. The two secondaries are connected in parallel and their final terminals are in series with the antenna circuit. More in detail, the low potential terminals of the intermediate coils are connected to the ground, the other terminals of the intermediate coils are connected to the low potential terminals of the secondary coils, and the high potential terminals of the secondary coils to the antenna loading coil. The intermediate coils S_5 are placed between the primary and secondary of each transformer in order to obtain a close coupling with the alternator.

The voltage at the terminals of the secondary winding of the transformer when the alternator is operated at normal speed is about 2,000. The normal output current is 100 amperes. It is thus seen that the alternator is designed for a load resistance of 20 ohms.

Since the antenna circuit is directly associated with the alternator circuit, any change in the rotative speed of this machine would throw the alternator circuit out of resonance with the antenna circuit; consequently it is easily seen that the speed variation of a radio frequency alternator for substantially constant output must be held within very close limits. The variable load imposed by telegraphic signaling has a tendency to cause a variation of speed that must be compensated for by some device which operates more critically than any of the mechanical and electrical methods of speed control devised for ordinary power use. The characteristics of any satisfactory governor must be such that a small variation of speed will effect a maximum change in power input to the device under control. To accomplish this, some mechanism must come into such a critical state at the speed to be maintained, that a low percentage of change in speed causes a high percentage of change in itself.

It can be shown that a change in speed of one-quarter of one per cent from that necessary to maintain resonance will reduce the antenna current in a station utilizing the wave length of New Brunswick—13,600 meters—to one-half its full value. This clearly infers that the speed variation must be much less than one-fourth of one per cent to maintain a constant output at the alternator. As a matter of fact, a regulation within *one-tenth of one per cent* is obtained by the Alexanderson speed regulator.

The necessity for close speed regulation becomes equally important when considered from the standpoint of the receiving station. With a modern receiving apparatus of low decrement, a very slight change in the wave length of the incoming signal will materially decrease the received current. A change of wave length or frequency is likewise detrimental when reception is obtained by the heterodyne or beat principle, for should the speed of the alternator vary markedly while signaling, the beat note may vary to the degree that will render it objectionable for ear reception. A variation, for instance, of 50 cycles in the alternator will cause the beat note at the receiver to vary 50 cycles, equivalent to a speed variation of 0.23 per cent at the wave length of 13,600 meters.

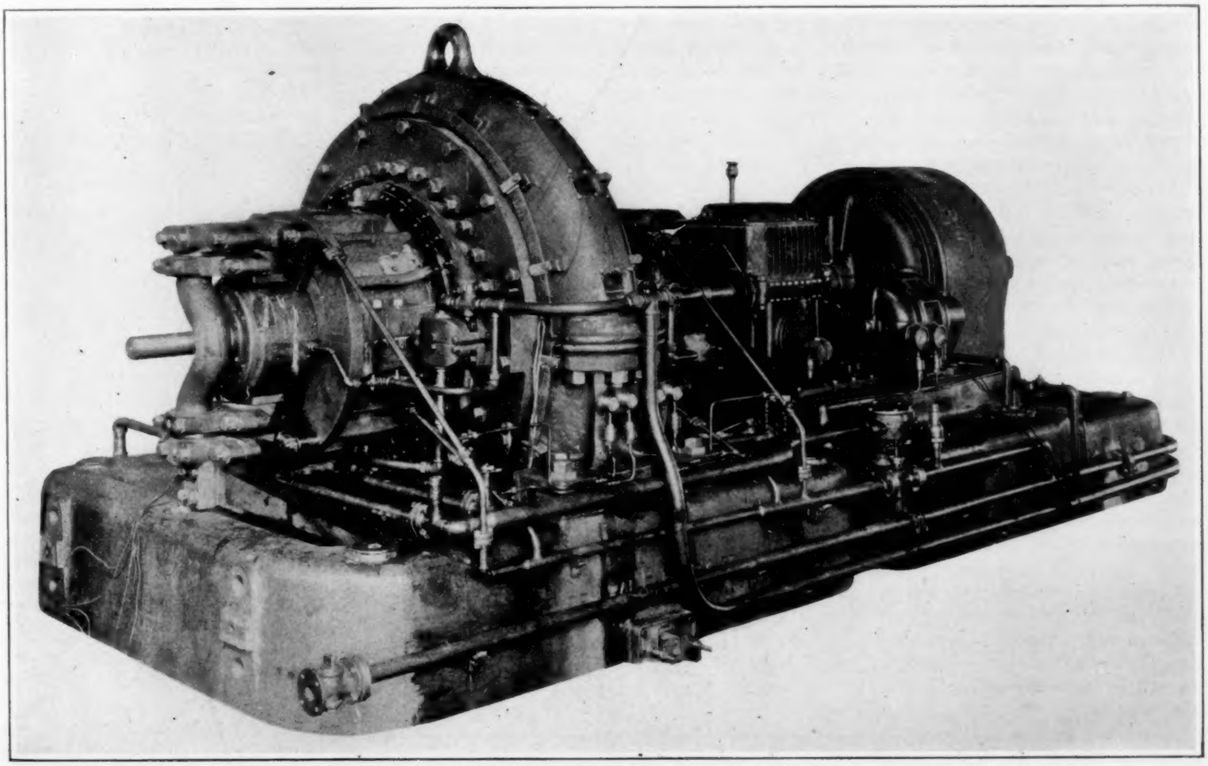


FIG. 4. A 200-KILOWATT ALTERNATOR WITH HIGH FREQUENCY TRANSFORMER REMOVED

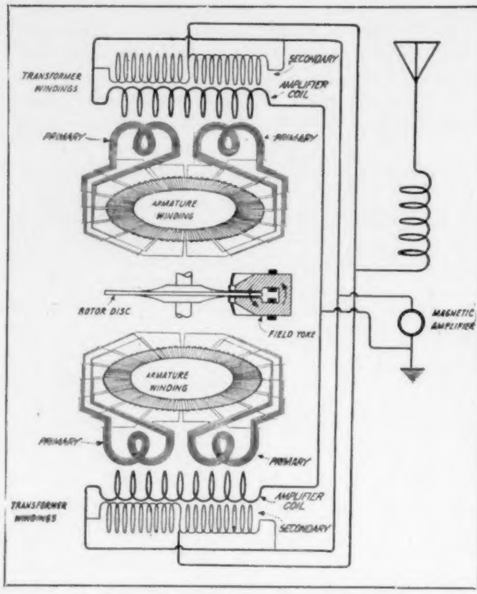


FIG. 5. SCHEMATIC DIAGRAM OF ALTERNATOR CIRCUITS

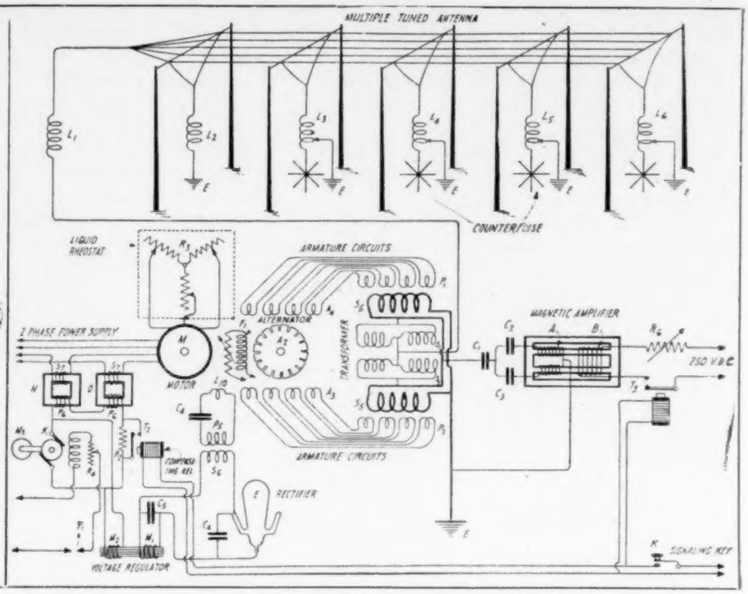


FIG. 6. FUNDAMENTAL STATION DIAGRAM OF 200-KILOWATT ALTERNATOR SET AT NEW BRUNSWICK, N. J.

A solution of the problem of speed regulation with a.c. motor drive was found by Mr. Alexanderson in the use of a *resonance circuit*, which is tuned to a frequency slightly above the frequency to be maintained at the alternator. This circuit is supplied with current from one of the armature coils on the alternator. The current in this circuit increases with alternator speed and, through the agency of a *rectifier*, a d.c. component operates on a *voltage regulator* connected in the circuit of the dynamo which supplies the saturation current for a set of *variable impedances* in the two phases of the motor supply circuit. The function of the regulator is to prevent, within established limits, either an increase or decrease of alternator speed. Additional compensation for the load imposed when signalling is provided by a *relay* which also operates through the d.c. control circuits to vary the line impedances mentioned above.

The multiple tuned antenna may be said to establish a radical departure from the types of antennæ formerly used for high-power radio transmission. The immediate object of the multiple antenna is to reduce the wasteful resistance of the long, low, flat-top aerials formerly used and to permit the length of such aerials to be increased indefinitely for the use of greater powers. In the case of the New Brunswick antenna, its resistance as a flat-top aerial—3.7 ohms—was reduced by multiple tuning to 0.5 ohm. The radiation qualities of the flat top are not impaired by multiple tuning as a series of tests have shown that with an equal number of amperes in either type, the *same signal audibility* is obtained at a receiving station, but there is an enormous saving of power in the case of the multiple antenna, as will be presently pointed out.

As shown in the station diagram, Fig. 6, the multiple antenna has, instead of the single ground wire usually employed, a number of ground leads which are brought down from the flat top at equally spaced intervals, and connected to earth through appropriate tuning coils.

The capacitive reactance of the flat top is thus neutralized by inductive reactance at six points to earth, instead of but one point as in the ordinary system. The inductive reactance in each down lead is therefore made six times the capacitive reactance at a given frequency. The multiple antenna is thus the equivalent of *six independent radiators*, all in parallel and resonant to the same wave length. Their joint wasteful resistance obviously is much less than that of an antenna with a single ground, and herein lies the saving of power which the Alexanderson antenna brings about.

The relative power inputs required by both types of antennæ for the same value of antenna current will be seen from the following illustration: To maintain 600 amperes in the multiple-tuned antenna at New Brunswick, at a resistance of ½ ohm, the power required is $600^2 \times 0.5$, or 180 kw. To maintain the same antenna current in a flat-top antenna with resistance of 3.7 ohms requires $600^2 \times 3.7$, or 1330 kw. The economy of power secured in the case of the multiple-tuned antenna is an important consideration from the standpoint of the cost of daily operation.

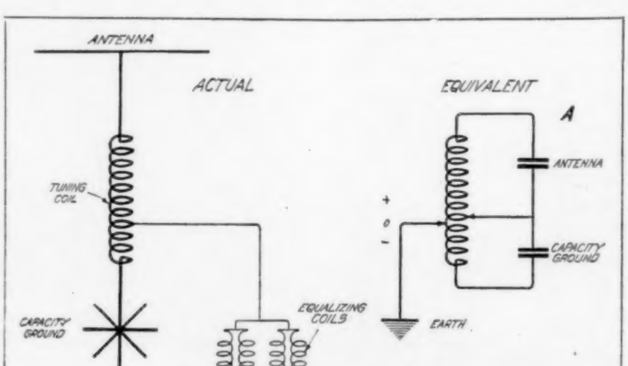


FIG. 7. DIAGRAM OF ANTENNA TO EARTH CONNECTIONS OF THE MULTIPLE TUNED ANTENNA

Prior to the advent of the Alexanderson antenna, theory and practice pointed to the desirability of a very high antenna structure for long distance communication at high powers, but as is well known, the cost of erecting an antenna increases very rapidly with the effective height. The multiple-tuned antenna, however, permits the use of a less expensive antenna structure, and gives the same signal audibility at a given receiving station as a high antenna of the old type *with less*

power. The example given above demonstrates quite conclusively that the multiple antenna will provide the same antenna current as the flat-top type antenna, but with only one-seventh of the power.

EARTH SYSTEM

The earth-wire system at the New Brunswick station is a combination of a *buried metallic* and a *capacitive ground.* Sixteen parallel copper *conductors* are laid underneath the antenna and buried one foot in the ground. They extend the entire length of the antenna and are spaced between towers somewhat as shown in Fig. 8. A network of wires and zinc plates are also buried in the ground around the station. At each of the five tuning points outside the station, connection is made from the antenna flat top to the sixteen underground wires.

In order to secure equal distribution of current through the buried ground conductors, *equalizing coils* are inserted between the tap on the down lead coil and the earth wires at each of the five tuning points outside the station, as shown in detail, Fig. 8. The function of the equalizing coils is to increase the impedance of the wires near the center and hence force current in the outside wires. Since the coils are wound in opposite directions they add no appreciable inductive reactance to the tuning circuits. In one instance, the use of these coils reduced the multiple resistance of the antenna system from 0.9 to 0.7 ohm.

A still better distribution of the earth currents at New Brunswick was obtained by using a capacitive ground commonly known as a *counterpoise*, which is erected underneath the antenna and a few feet above the earth. A plan view of the counterpoise is shown in Fig. 9. The capacitive ground may be considered as a combination of a tuned and a forced oscillation circuit, and it has the effect of drawing the current from the ground circuit more uniformly than with wires lying on the ground or buried beneath the surface. In practice the total current in the down lead may be distributed between the capacitive ground and the wire ground in any desired ratio. The effect of adding this unit to the system at New Brunswick was to decrease the multiple antenna resistance from 0.7 to 0.5 ohm. The capacitive ground may be divided into separate units for each tuning down lead or the units may be connected together as shown. A schematic diagram of the connections between the flat top and the capacitive and earth-wire grounds is shown in Fig. 7. The equivalent circuit is given at the right of the drawing.

MAGNETIC AMPLIFIER

Telegraphic control of the large antenna currents involved in high-power radio transmitters has ever presented a difficult problem. Particularly has this been true when signalling at high speeds. Rapid signalling obviously requires some device that will not cause destructive arcs and will provide the desired modulation of antenna power without taking upon itself the burden of carrying the full power of the system during the intervals between signalling.

The *magnetic amplifier* is a device which meets these ex-

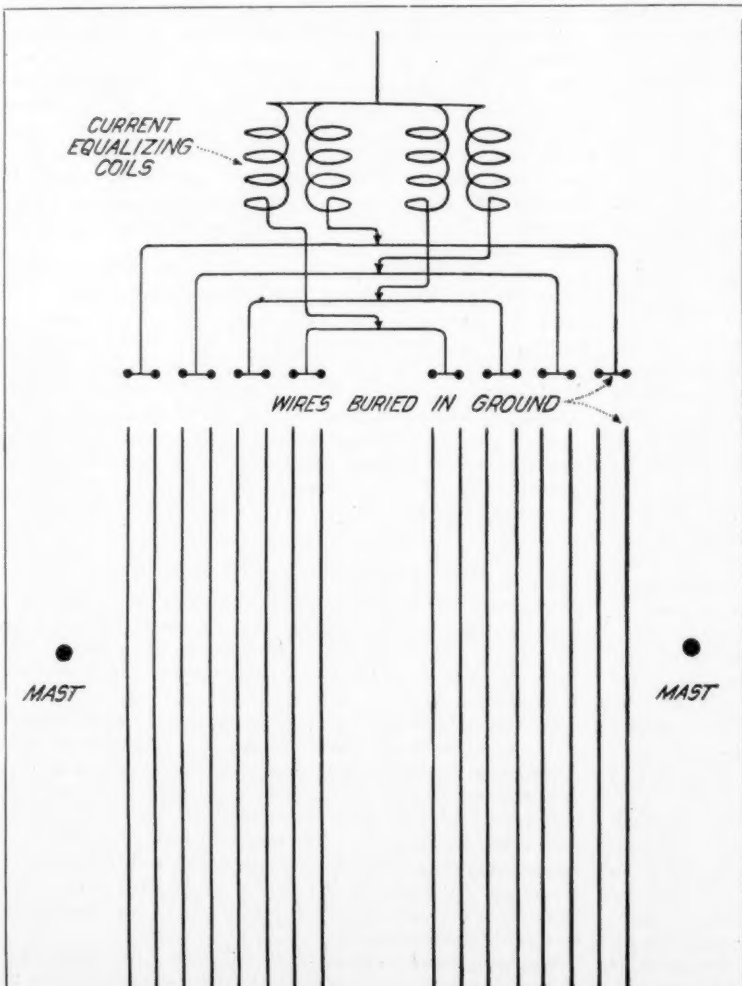


FIG. 8. THE EARTH-WIRE SYSTEM AT NEW BRUNSWICK

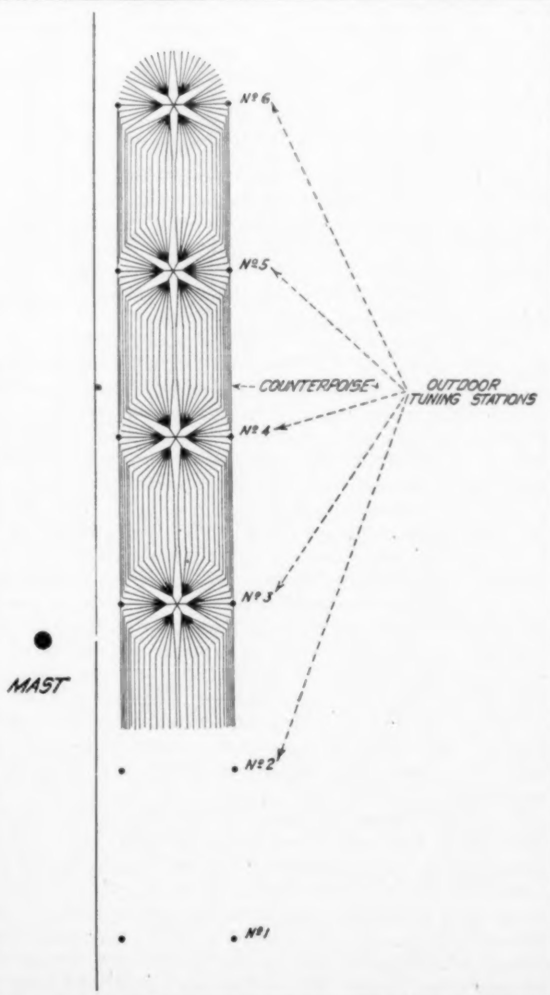


FIG. 9. PLAN VIEW OF THE COUNTERPOISE

acting requirements, for it provides a non-arcing control with a minimum current in the key circuit, and it takes within itself only a small proportion of the total alternator output.

The magnetic amplifier in general may be described as a *variable impedance* which is connected in shunt with the external circuit of the radio frequency alternator. Its function is to *reduce the voltage* of the alternator and *to detune* the antenna system when the sending key proper is open, and to perform the opposite functions when it is closed. Thus when the sending key is open the amplifier short-circuits the alternator and detunes the antenna system, thereby reducing the antenna current to a negligible figure. When it is closed the output of the alternator is fed to the antenna system.

A general idea of the operation of the amplifier can be obtained from the fundamental circuit. Fig. 6, where it will be noted that the radio frequency coils A and a control coil B are mounted on a common iron structure and are so disposed that the effect of the control coil upon the radio frequency coils is obtained solely through the agency of flux variations within the core. The impedance of the amplifier is dependent upon the degree to which the iron core is saturated by the control winding. The saturation in turn varies as the current fed into the control circuit. When the control circuit is closed the alternator is short circuited; when it is open, the alternator assumes normal voltage and its output flows into the antenna system.

The magnetic amplifier has been employed in experimental telegraphic signalling at speeds above 500 words per minute, at which rates it functions without lag. It is equally applicable as a *modulator* of antenna power in *radio telephony*, in which case the control current of the amplifier is modulated at speech frequencies by a bank of Pliotron (vacuum valve) amplifiers, which in turn are controlled by an ordinary speech microphone.

FUNDAMENTAL STATION CIRCUIT

The fundamental *circuits of a typical Alexanderson alternator station* are shown in Fig. 6. Beginning at the left of the drawing it is to be noted that a source of two-phase, 60-cycle alternating current drives an *induction motor* M, having a wound rotor, the circuits of which include a liquid rheostat R_3. The motor is connected to the *radio frequency alternator* through a helical step-up gear.

The alternator armature coils are indicated at A_3, A_4, the field coils at F_1, and the rotor at A_2. There are two sets of armature coils one on each side of the rotor, which as already mentioned, are divided into 32 sections on each side. The windings on each side connect to the primaries of two transformers shown at P_1, P_2. The primary of each transformer (see Fig. 5) contains two complete turns of 16 wires in each turn, which carry the current developed in the 32 sections of the armature coils on each side of the rotor. As can be seen from the diagram, there is no direct electrical connection between the armature circuits leading to the transformer primary, but the individual primary circuits are disposed so that their magnetic fields at any instant are in the same direction, that is, their fields combine to operate on the secondaries S_1, S_2. In addition to the primary and secondary coils, the two transformers have intermediate coils S_5 which are connected in parallel and shunted by the magnetic amplifier coils A. The coils S_5 are connected in series with the antenna system, and are also closely coupled to the primary and secondary.

The *multiple tuned antenna*, shown in the upper right hand part of Fig. 6, is a long, low, horizontal aerial of the Marconi type, from which are brought down leads to earth, which include the tuning inductances L_1, L_2, L_3, L_4, L_5, L_6. For any given wave length the *joint inductive reactance* of the down lead circuits $L_1 \ldots L_6$ is made *equal to the capacitive reactance of the entire flat top* at the operating frequency or wave length. The multiple antenna is therefore the equivalent of *six independent radiating systems* resonant to the same wave length, and for all practical purposes, the oscillating currents in them flow in phase.

The magnetic amplifier, shown to the right of the diagram, comprises the parallel-connected *impedance coils* A, which are connected in series with the *condenser* C_1 and the transformer *amplifier* coils S_3. B is the *control* coil, wound to include both branches of the windings A, which is fed with direct current, regulated by the rheostat R_6. When the control circuit is closed the impedance of the amplifier coils A become a minimum; when it is open the impedance is a maximum. In the former case the alternator is placed on short circuit and the antenna is detuned; in the latter case the alternator assumes normal voltage and its output flows into the antenna system. In practice the capacity of C_1 is selected to neutralize the inductance of windings A for some value of current in the control coil.

The circuits of the *speed regulator* appear in the lower left part of the drawing. Note is to be made first of the variable impedances N and O in the motor supply line with their d.c. control coils P_6 and the variable impedance coils S_7.

The extremely close speed regulation essential to alternator operation is obtained from the *resonance circuit* L_{10}, C_4, P_5, the coil L_{10} being one of the alternator armature coils. This circuit is made resonant to a frequency slightly above the normal frequency at which the alternator is to be operated and the current developed therein acts inductively on the circuit S_6, E, M_1—E being a rectifier. The latter rectifies the radio frequency current and sends a d.c. component through M_1, which acts with an increase of speed to decrease the voltage held by the *voltage regulator* M_2 T_1 on the generator K_1. This increases the impedance of the coils S_7 and therefore tends to reduce the speed of the driving motor. As the speed now falls the current in the resonant circuit falls off and likewise that in the coil M_1. This permits the voltage held by the voltage regulator to increase, and therefore acts to reduce the motor supply line impedance and thus increase the speed. A given *mean voltage* is thus maintained in the control circuit by generator K_1, which depends upon the magnitude of the control current in M_1. This keeps the speed variation within exceedingly close limits.

Additional compensation for the load imposed by signalling is obtained by the *relay* T_2, which shunts the resistance R_2 when the sending key is closed. This decreases the impedance of N and O and increases the input to the motor by an amount equal to that imposed by the load, without change of speed. It therefore lightens the duty of the speed regulator proper, making it responsible only for slight irregularities in the power supply or for variations occasioned by the compensating device. The same speed regulation can be obtained at other alternator frequencies by tuning the *resonance circuit* to a suitable frequency.

RECTIFIER FOR SMALL CURRENTS

At a meeting of the German Electrotechnical Association a type of rectifier was described that is suited for supplying very small currents of the order of 0.5 to 3.0 amperes. The value of such an apparatus in the laboratory will be fully appreciated.

The rectifier consists of a bulb containing a gas such as argon, and provided with cathodes of metals that can be easily volatilized, such as thallium, alloyed with heavy metals such as mercury, cadmium, or lead. Cathodes of such alloys have the property of maintaining a stable arc with far lower currents than mercury cathodes. The apparatus is connected in a manner similar to a mercury vapor rectifier, with the exception of the starting gear, which in the argon rectifier is a vaccum interrupter connected in parallel with one of the two circuits of the rectifying tube.

The efficiency of tubes of 30 to 100 watts capacity is about 65 per cent.—Skaupy, *Elektrotechnische Zeitschrift*, April 29, 1920. Abstracted by the *Technical Review*.

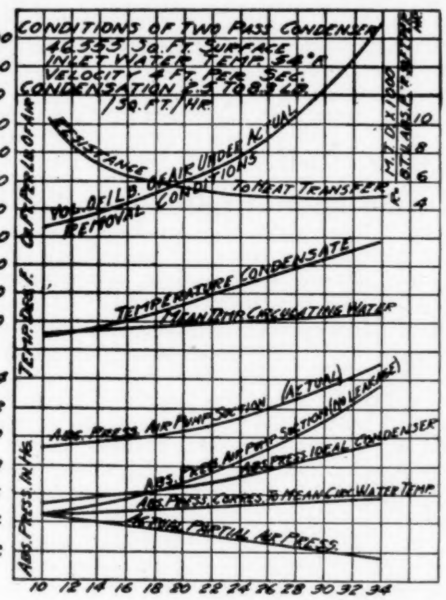
Limitations of High Vacuum*

Difficulties That Must Be Overcome in Approaching Conditions of an Ideal Condenser

By A. D. Bailey

THE question of high vacua has interested plant operators recently more on account of the efficient air removal devices now being used. The tendency toward the use of high vacuum condensing equipment has been continually to demand higher vacuum, with the idea that this means great economy. Under ordinary conditions this is admittedly true, but the conditions under which greater vacua could be obtained introduce a number of factors which may more than offset any possible gain in economy.

It appears that a large number of plant operators have gone



LOAD IN THOUSANDS OF KILOWATTS

FIG. 1. CURVES ILLUSTRATING SOME IDEAL CONDENSER CONDITIONS WITH NO LEAKAGE OF AIR

on demanding higher vacuum under their present equipment without regard to the difficulties to be overcome. Others have maintained that there is a definite limit to the vacuum obtainable beyond which it would not pay to go. The former advance the usual theoretical reasons for higher vacuum, but produce no actual data to substantiate the claims, which for this reason are nothing more than professional opinions.

On the other hand, the claim that there is a definite limit to economical vacuum has at least partial substantiation by experiment on equipment as it is, but this does not necessarily indicate the possibilities of a turbine-condenser equipment designed originally for high vacuum. By high vacuum is meant an approach to the conditions of an ideal condenser working under average conditions as to temperature and velocity of circulating water.

As no real data are available to show just what the limitations of maximum economical vacuum are, the discussion herein is, therefore, confined mostly to the difficulties and problems that future developments must overcome in approaching the conditions of an ideal condenser. It is ordinarily considered that higher vacuum is a function of the condenser only, but, as a matter of fact, it involves also the design of the turbine, particularly the final expansion, tightness of turbine casing and condenser, and the ability to remove highly rarefied air.

*From *Electrical World,* June 19, 1920.

GOOD PRACTICE IN CONDENSER OPERATION

For the purpose of illustration in this discussion, the conditions of a two-pass surface condenser operating in connection with a 30,000 kw. Curtis-Rateau turbine are used and shown in Figs. 1 and 2. These conditions can be considered at the present time to represent good practice, and the opportunities for and chances of further development are as good with other types of generating units, or possibly better.

One of the most important factors governing the maximum vacuum possible is, of course, the amount of air to be removed Condenser manufacturers claim that the amount of air to be removed from a condenser is directly proportional to the steam condensed. This may be true of a perfectly tight condenser wherein all the air enters by entrainment with the feed water. The experience of actual operation shows that a perfectly tight condenser and exhaust casing is seldom found.

Referring to Fig. 1, it is shown by the curves of partial air pressure and resistance to heat transfer that the amount of air to be removed was not proportional to the steam condensed, but was actually more at low loads than at high loads. This fact is an indirect indication that the air in the condenser was largely a matter of leakage rather than entrainment with the feed water. Thus it can be seen that a condenser which is tight under all load and temperature condi-

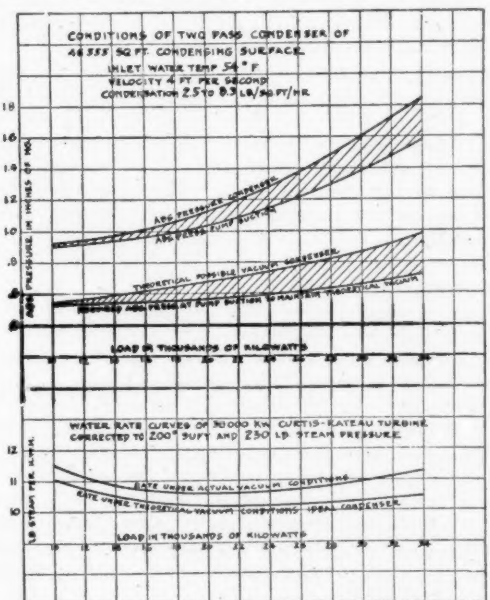


FIG. 2. CURVES SHOWING ACTUAL CONDENSER PERFORMANCE UNDER WORKING CONDITIONS

tions offers opportunity of increased vacuum. The vacuum conditions of no air leakage or entrainment are shown in Fig. 1 for all load conditions. This is probably impossible of attainment, but there is still a chance of improvement in this respect.

A limiting factor of actual vaccum is the temperature of the condensate, inasmuch as a vacuum greater than that corresponding is impossible. It has been claimed that there were high-vacuum possibilities in reducing the condensate temperature, the limiting possibilities of which would be a mean of the circulating water temperatures. Referring to Fig. 1,

it may be noted that this hypothetical vacuum is greater than that possible with an ideal condenser operating under the conditions stated and is therefore impossible. Any gain in economy resulting from increasing the vacuum by reducing the condensate temperature would have to more than balance that lost to the feed water temperature. A heat balance shows only slight possibilities at high loads.

The most important limitations to high vacuum have to do with the design of the turbine itself, which is designed for a definite vacuum at its most economical load. The volume of a pound of steam at 1 in. absolute pressure is 652 cu. ft. and at 0.5 in. absolute pressure is about 1,260 cu. ft.—almost twice the volume. On the present equipment this would mean a corresponding increase in the exit velocity from the last row of buckets, which means a large increase in the lost kinetic energy which is in proportion to the square of the velocity. Such incomplete data as are available show that, at low loads of from 10,000 to 12,000 kw. (Fig. 2), there is an increase in economy of about 3 to 3.5 per cent, while at higher loads no increase is indicated over a range of 1 in. to 0.5 in. absolue pressure. These percentages at 0.5 in. absolute pressure were, however, assumed as actual conditions of 0.5 in. absolute condenser pressure could not be obtained.

Turbine bucket designs require that the speed of the bucket bear a proper relation to the steam velocity. If this relation is to be carried out under higher vacuum conditions, difficulties of design in the last stage buckets nullify any possible gain in economy. If buckets are made too long, the velocity conditions at the tip on account of the flare would be such that steam would flow through without doing any work. If high steam velocities are used in the last stage it must necessarily follow that a greater proportion of the work done must be accomplished there, and this would mean less efficiency than if designed for a lesser proportion of work.

It would then appear from the foregoing that there are limitations to economical vacuum, but owing to the lack of complete data pertinent to this question no exact limit for any set of conditions can be stated at this time. It does not appear that the conditions of an ideal condenser, or vacua of from 0.5 to 0.9 in. under the conditions as shown by Fig. 1, are impossible of attainment, if increased economy is the governing factor.

Air Drive for Motor Cars*

The Helica, a Novel Type of Automobile Driven by an Airplane Propeller

When we consider the method by which an ordinary automobile is propelled we observe that in order to overcome the resistance of the air it finds a point of support upon the ground. If the resistance of the air could be eliminated only 60 per cent as much horse-power would be required to move the vehicle. Furthermore, we must add to the power required for penetrating the air that which is absorbed by the various organs of transmission from the motor to the wheel. For several years inventors have been trying to modify the manner in which vehicles are propelled and one of the first attempts along this line was the employment of a propeller such as those used in airplanes and in dirigibles. As a matter of fact this has been done with much success in the cases of the hydroplane. Our readers may remember that the Lambert hydroplane was used with success during the war in Mesopotamia.

Air-screw propulsion can also be used successfully upon sleds, where there is no friction between the vehicle and the ground. Other efforts with screws and spurred wheels have yielded rather barbarous mechanisms without a practical amount of speed. The propeller with its simple mechanism is readily applied to a light sled which slides easily upon the ice finding the required point of support for the propulsion in the very air which it penetrates. If we turn to traction upon the ground it becomes evident that the aerial propeller keyed directly upon the engine shaft makes it possible to get rid of many of the delicate organs necessary in the construction of an ordinary car, such as speed gears, differentials, cardan joints, clutches, etc.

The work done by a wheeled vehicle, at the moment of starting, directly estimated, attains 54 per cent at most, whereas upon a rapidly moving vehicle driven by a propeller 70 per cent can readily be obtained.

Some of our neighboring countries have been carefully studying this question with the hope of using their stocks of airplane motors to drive railway cars. All that is required is to install a motor and propeller at one end of the car. The present scarcity of coal and the large number of motors put out of commission by the armistice, make this a very desirable solution, at any rate for the carrying of passengers upon lines where the traffic is light.

Still more interesting is the idea of applying such a propeller to automobiles. To begin with the dead weight would thus be considerably lightened. Then, too, many delicately constructed and expensive parts could be done away with and, finally, the car could be built in a rational form specially designed for the purpose of penetrating the air. Such a propeller-driven vehicle is no longer a mere dream. It actually exists and has been tested with good results, and is being manufactured.

The first model, which is illustrated herewith, made its appearance, in fact, even before the war, but its inventor, M. Leyat, desired to subject it to severe tests so as to make sure of its effectiveness. The first type built actually went to the front where it made trips necessarily rather rough in character. This still exists and will one day make its reappearance. It is not astonishing, therefore, that this new kind of automobile has been rapidly gaining friends.

The motive mechanism consists of a V-type, two-cylinder, air-cooled motor, developing eight horse-power. This motor is directly connected with a four-bladed propeller placed in front of the car. The diameter of this propeller which does not exceed the width of the car is 1.40 m. It is surrounded by a propeller guard. Thus we dispense with the clutch, transmission and differential; only the starter and the brakes remain as indispensable apparatus for driving the car. The body of the vehicle consists practically of the car alone, and for this reason it can be built in the best possible form from the point of view of aerodynamics, i. e. tapering toward the rear, swelling out more at the front and without projecting portions which might interfere with its sliding through the air. Except, of course, the axles and wheels and the mudguards which have a horizontal generating surface, all other parts are included in the body of the car. Absolutely the only thing which projects outside is the head of the driver, protected by a wind shield. In the first model, indeed, even the driver was entirely enclosed in the car. The framework of this car is composed of four principal longerons made of wood, connected by the outer plating. These longerons act like the ribs of an airplane, but the truss which they constitute is established under very good conditions, since its height is great with respect to its length. The entrance door permits the driver and a passenger to take their places in two seats arranged in tandem form; these fold to permit passing. At the rear are found a tool box, a place for luggage and a gasoline tank.

Starting is effected by a cable which drives the shaft by

*Abstracted from *La Nature* (Paris), June 8, 1920.

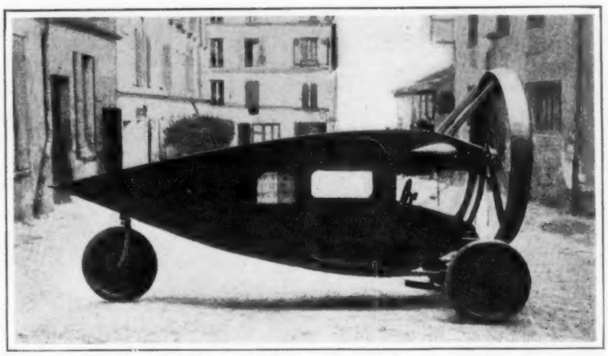
passing over a pulley. The motor is started from outside the car by means of the cable. The driver stands on the step near the door and has all the controls at hand. This system of starting does away with the danger of a back fire and makes it unnecessary to have the electric starter.

Leaf spring suspension is provided at the fore part, while at the rear a spiral spring is used. While in the original car a single wheel was provided at the rear, in later models two rear wheels are employed.

A very carefully studied point is that of the braking. The principal brake is upon the fore wheels. It is a well-known fact that when a rear brake alone is employed, as is universally done, it often causes dangerous skidding. In the Hetica the fore wheels as well as the rear wheels are fitted with drum brakes. When traveling at 35 km. (22 miles) per hour, a sudden stop can be made within a distance of five meters (16 ft.). When at rest and when stopping or starting the motor the brake is applied to all four wheels, but provision is made for forward braking alone under normal running conditions.

In the Helica car the braking of the forward wheels is of the greatest simplicity, since these are neither motive nor steering wheels. This detail is important by reason of the fact that the braking of the forward wheels in an ordinary automobile is often dispensed with in spite of its evident advantages, because of the complex structure required due to the fact that the forward wheels act as steering wheels.

In spite of the low power of the motor (only 8 hp.), the lightness and the rational form of the car and the absence of mechanical transmissions, makes it possible for it to attain a velocity of more than 80 km. (50 miles) per hour, though only consuming about 4 liters of gasoline to every 100 km. (60 miles per gallon) of distance. The air currents produced by the passage of the car are less serious and less dust is raised; furthermore, the lightness and the absence of motive wheels prevents any wear of the road bed, and as we have said there is no skidding to be feared. At starting the wind is imperceptible for anyone outside the path of the vehicle. At the rear the full strength of the velocity of the wind is less thán 30 km. per hour and this only when the starting is difficult.


THE ORIGINAL HELICA, BUILT IN 1914

The ease with which the machine is driven makes it an admirable city car, while its velocity and low consumption of fuel enable it to make long and rapid journeys. Finally, the complete weight of the car is only 225 kg. (496 pounds); wheel base, 2.95 m. (9 ft. 7 in.); tread, 1.40 m. (4 ft. 7 in.). In the colonies especially, where roads are very imperfect, the ordinary car often sticks fast in the sand and mud.

The Helica has no driving wheels, hence it does not make ruts which inevitably occasion sinking into the ground. Thus it can go over all sorts of ground without heavy wear and tear upon pneumatic tires, and even if it should be mired it is easy to set it free by reason of its light weight.

MEASURING THERMAL EXPANSIONS

IN the SCIENTIFIC AMERICAN MONTHLY of May, 1920, pp. 457-460 we published an article entitled "Measuring Thermal Expansions" by Arthur W. Gray describing the stretched wire dilatometer. As our copy was defective a paragraph was omitted and there were two typographical errors to which the author has called our attention. The matter immediately preceding the first subtitle on page 458 should read:

"Molybdenum repeats better than most substances, and is therefore, well suited for exhibiting the reliability of expansion apparatus.

"The precision easily attainable with stretched wire expansion apparatus is also well illustrated by the routine practice of plotting to a large scale the deviations of individual measurements from the quadratic which best represents an entire series. This method is useful not only for adjusting observations, but also for locating transition regions with precision, as can be seen by examining the deviation curves published by Merica and Schad."

On page 459 the word "or" in line 15, under section entitled "Sources of Error" should have been "of." In the tenth line the first column of page 460 "as the expansion" should have read "by 5/4 the expansion."

LIST OF ARTICLES ON THE COMPOSITION AND THE NUTRITIVE VALUE OF CORN

CORN forms such an important article of food for both men and the farm animals, and is also such an important agricultural product in the United States, that it is hardly surprising to find that a large amount of study of its composition and of its value in nutrition has been reported in the scientific journals from time to time. A bibliography of all such articles and agricultural experiment station bulletins is very soon to be issued by the National Research Council in the form of a limited number of mimeograph copies. The material has been collected by M. Helen Keith at the Illinois Agricultural Experiment Station. This is not only a list of the articles found, giving their full titles and references, but includes also an extensive classification of the references showing the specific subjects studied. This enables one to turn readily to all of the work bearing on any particular phase of the whole subject. Stockmen and food and nutrition workers generally will welcome this aid to their study which may be obtained by applying to the National Research Council, 1201 Sixteenth Street., Washington, D. C.

CELLULOID WITHOUT CAMPHOR

IN the May issue of *Chemical Age*, page 153, is an article dealing with the latest step in the manufacture of celluloid, which is the perfection and commercial application of a method for making celluloid without the use of camphor in any form. It will be recalled that celluloid was found in a search for a substitute for ivory to be used in billiard balls.

The principal objection, besides inflammability, has been to the odor and taste of celluloid, which is due to the camphor or camphor substitutes. This taste and odor is found whether refined natural camphor is used or the synthetic material in the manufacture of which turpentine is the starting point. By eliminating camphor it is stated that the inflammability of celluloid is reduced by from 50 to 80 per cent, resulting in a slow burning, rather than a highly inflammable, compound. The new compound has neither taste nor odor, and while the process has not been cheapened thus far, it is expected that this desired end can be achieved with the further development of the process. The new celluloid has the same degree of pliability and, in general, the same physical characteristics as the older form. It has a higher degree of transparency. The new material, as yet, has not been made adaptable to all the uses for which celluloid is favored, but it is expected that the necessary improvements can be made in the product.

Aerial Lighthouses

Difference Between Requirements of Marine and Aerial Navigation

THE provision of lighthouses for assisting aerial navigation at night presents several important points of difference from the conditions to be fulfilled in providing lighthouses for marine navigation. It is clear, for instance, that while the marine light has to be visible for more or less constant height above the sea level, the aerial light has to be visible from a machine which may be flying at any altitude lying between wide limits, and should be capable of being seen from a point directly over it. In view of the increased elevation from which the aerial light is seen the candle-power of the installation has to be made, or should be made, considerably greater than in a marine lighthouse fulfilling a corresponding function. Thus a light placed 150 feet above the sea level would, mist and fog being absent, first appear above the horizon to an observer stationed 55 feet above the sea when his ship reached a point 22½ miles from the light. To a pilot of an aeroplane flying at a height of only 2,000 feet above the sea the same light would become visible at a range of 65 miles, so that if the light is to appear with the same brightness to both observers when it is first picked up the aerial lamp ought to have a candle-power nearly nine times as great as the lamp in the marine lighthouse.

Granted the possibility of constructing a suitable lighthouse for aerial navigation, the question of where it should be placed demands special consideration. As in marine work, the aerial lighthouses required are of two broad kinds, namely, "land-fall" lights, such as the Eddystone, the Lizard, and the Fastnet lights, and local lights corresponding to the marine lights, whereby a ship's course is guided along the coast. It is evident that the aerial "land-fall" lights should not be placed so that there is the least chance of their clashing with or being mistaken for the corresponding marine lights. To avoid such clashing it would appear desirable, where possible, to combine the marine and aerial lights in the same house. As regards the local lights required to guide aircraft from point to point overland to their objective, some difficulty may arise from the fact that a light is sometimes much less visible over land than over sea, particularly in flat country, where ground mists and local fogs are of frequent occurrence. A less important source of possible trouble lies in the fact that local aerial lights may possibly be mistaken for lights in a town or *vice versa* unless the route and the aerodome lie well away from populated centers. During the war the lighting restrictions incidentally obviated this difficulty and permitted the use of a type of low-power local light, which today would be relatively of very little use.

Lighthouses for marine purposes have passed through many stages in the course of their evolution. Today lights equipped with parabolic metal reflectors are almost obsolete, and in their stead we find the beam concentrated and directed by means of glass optical apparatus. Of these modern lights there are, broadly speaking, two general forms, namely, the "fixed section" type and the "flashing" or "revolving section" type. In the fixed section type the illuminant is frequently acetylene. The optical apparatus in this form is arranged to concentrate and deflect only the vertical components of the rays of light coming from the burner. The occultation of the light, if required, is effected by means of a device which alternately lights and extinguishes the burner, the optical portion of the light not being arranged to revolve.

*From the *Engineer* (London) May 14, 1920.

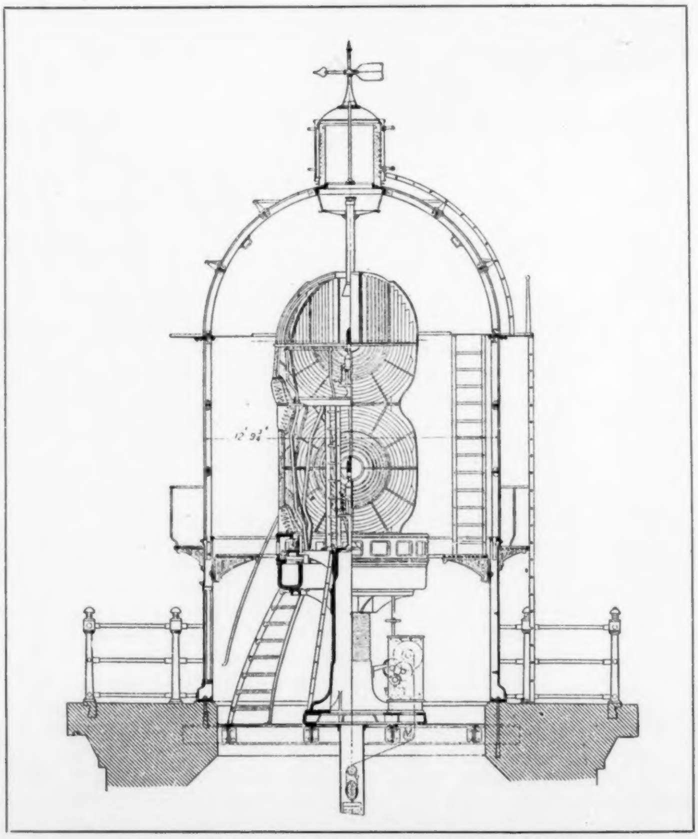


FIG. 1. COMBINED AERIAL AND MARINE LIGHT

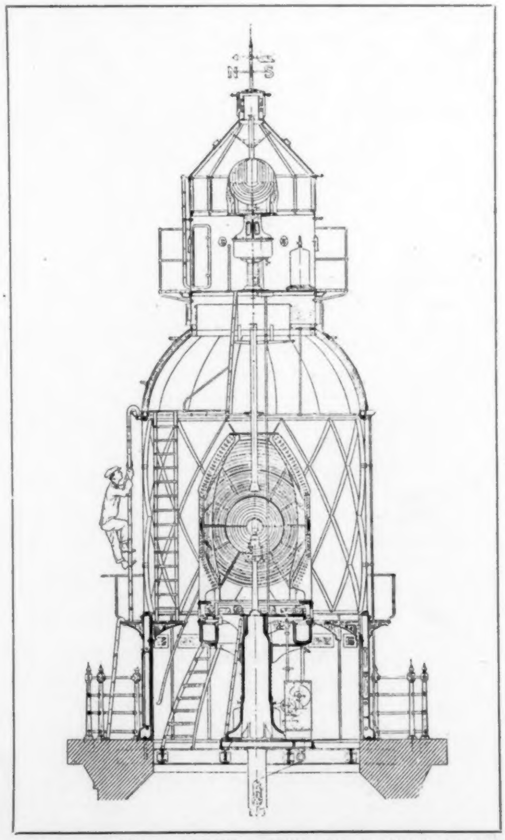


FIG. 2. AERIAL LIGHT ADDED TO MARINE LIGHT

The length of flash obtainable with this form of light is practically unrestricted, but the candle-power is perforce low. The general design of the light readily permits it to be run without attendance. In the revolving section form of light, on the other hand, the burner, frequently of the incandescent type supplied with oil gas or petroleum vapor, is surrounded by several built-up lenses, each of which concentrates both the vertical and horizontal components of the light rays coming from the burner and directs them as a substantially parallel beam towards the horizon. The lens system is mounted on a pedestal and is rotated so that at a distance an observer on a ship sees the light as a series of flashes, the frequency of which depends upon the speed with which the optical system is rotated and the number of lenses which it contains. In general, the duration of the flash given is now fairly well standardized at 0.2 sec. If necessary, this period could possibly be increased to about one second, but if it had to be made longer the frequency of the flashing would have to be reduced. Up to a certain size revolving section lights can be arranged to be operated without regular attendance, but for very powerful lights the presence of a keeper is desirable.

The candle-power obtainable with revolving section lights is very much greater than that from fixed section lights. As a consequence of this fact we find all important lighthouses equipped with apparatus of the revolving section form, the fixed section type being commonly used in minor positions. It follows, therefore, that for aerial lighthouses corresponding to marine land-fall lights the revolving section form would naturally suggest itself, while for local lights required to guide aircraft to their objective fixed section lighthouses might be used.

In Fig. 1 is shown the arrangement of a combined maritime and aerial light for use at important stations. The lantern consists of a pedestal of cast iron plates, on top of which is fixed a framing of steel standards and gun-metal astragals, the sides and dome being glazed with three-eighths in. polished plate glass. The opitcal apparatus inside the lantern revolves on mercury and is rotated by clockwork mechanism driven by a falling weight. The lower portion of the optical apparatus consists of four panels of refracting and reflecting prisms of 90 deg. angle, which deliver the light as a horizontal beam. The burner is of the standard type used in lighthouses, burning vaporized petroleum, and has a mantle 110 mm. in diameter, giving an intensity of 3,500 British standard candles. The upper or aerial portion of the optical apparatus comprises four panels of refractors and reflectors, throwing a beam a few degrees above the horizontal, and, above these panels, reversed fixed section refractors and reflectors throwing a beam extending from a few degrees below the horizontal to within a few degrees of the vertical. The aerial portion is lit by an incandescent oil burner of the same size and type as that used in the maritime portion. The total floating weight of the combined apparatus is about 4¾ tons.

The design illustrated in Fig. 2 represents the addition of an aerial light to an existing maritime light. The lower portion is a modern maritime apparatus. The roof of the lantern has, however, been altered to take the lantern of the aerial light. Ventilation for the marine light is provided at the junction of the two lanterns. The upper portion of the aerial optical apparatus consists of fixed section lenses placed horizontally, and illuminates an angle extending from a few degrees below the horizontal to a few degrees from the vertical. The lower portion of the same apparatus emits a very strong beam, the axis of which is about 4 or 5 deg. above the horizontal, with the lowest divergent ray just horizontal. This beam could be seen by an airman at an altitude of about 10,000 feet when 22 miles distant from the lighthouse. The general details of the clockwork revolving mechanism follow modern practice. The aerial light is revolved by the same mechanism as the marine light, so that the flashes of the two portions may synchronize and thus avoid possibility of confusion to mariners.

MOTOR GASOLINE FROM HEAVIER HYDRO-CARBONS

PROF. F. W. PADGETT of the University of Oklahoma has prepared a very convenient and valuable summary of the processes involved in the preparation of motor gasoline from heavier hydro-carbons by cracking processes which comprises a useful set of data for reference purposes. This appears in the July number of *Mechanical Engineering*, the journal of the American Society of Mechanical Engineers.

The commercial processes for the production of gasoline from the heavier hydro-carbons are classified under the pressure still or two-phase cracking system, the pipe still, generally known as the single-phase cracking system, the use of catalytic agents at atmospheric pressure, combinations and modifications of two or more of these methods, and processes involving principles not included under these headings, but involving somewhat similar apparatus or the use of pressures.

As the author points out, the last eight years has seen numerous patents granted, involving almost every conceivable form of apparatus designed to secure hydro-carbons within a gasoline range from hydro-carbons having a higher boiling point. Some have the object of producing a gasoline comparable with what may be termed the natural product; others are along radically new lines, and still others aim to avoid the deposition of coke in the cracking process.

The article presents in interesting fashion details with reference to such familiar processes as the Burton, the Greenstreet, Hall and Rittman processes, pointing out their fundamental differences and the principles upon which they operate. The aluminum chloride process of McAfee is outlined. In this the oil is heated and stirred in a still in the presence of anhydrous aluminum chloride or other anhydrous salt of aluminum. Before treatment the oil must be freed from water and a quantity of catalyst equal to a maximum of eight per cent by weight of the charge is added before distillation is begun. The fractionating towers are interposed between the still and the condenser, so that the higher boiling vapors may be returned to the still along with aluminum chloride which has been vaporized and carried out. The distillation is continued slowly at a temperature of about 500 to 550°F. over a period of from 24 to 48 hours, the method yielding 15 per cent or more of gasoline from residual oils.

The author concludes his presentation with a discussion of the composition and refining of distillates obtained by the cracking of higher hydro-carbons, and reference to certain experiments undertaken by him to determine the practical refining conditions for cracked distillates so far as color, odor and stability are concerned. Constants upon unrefined pressure gasoline distillate and the natural gasoline distillate, both in the same crude petroleum, have been determined, and it has also been found that the best results, so far as color and odor are concerned, are secured by direct treatment of the pressure still gasoline with concentrated sulphuric acid at the freezing point followed by redistillation. The work involved in this careful comparative study has just begun and may be expected to yield a series of interesting results.

THE LONGEST FERRY LINE IN THE WORLD

A NEW ferry line, the greatest and longest in the world, is planned to run between England and Sweden. It is said that the Swedish governmental system of railroads has already carefully worked out the details of this project. A tremendous ferry boat with a length of almost 12 meters and with engines furnishing about 12,000 hp. is to travel daily between Sweden and England, bearing upon its huge decks freight trains 48 cars in length. Besides this there will be provisions for taking travelers from the first to the fourth class, together with dining rooms, promenades, and other agreeable features. The journey requires about 33 hours. After arriving on terra firma the freight train at once proceeds upon the English or Swedish tracks as the case may be. It is obvious that a tremendous saving both in time and in labor can be thus accomplished.

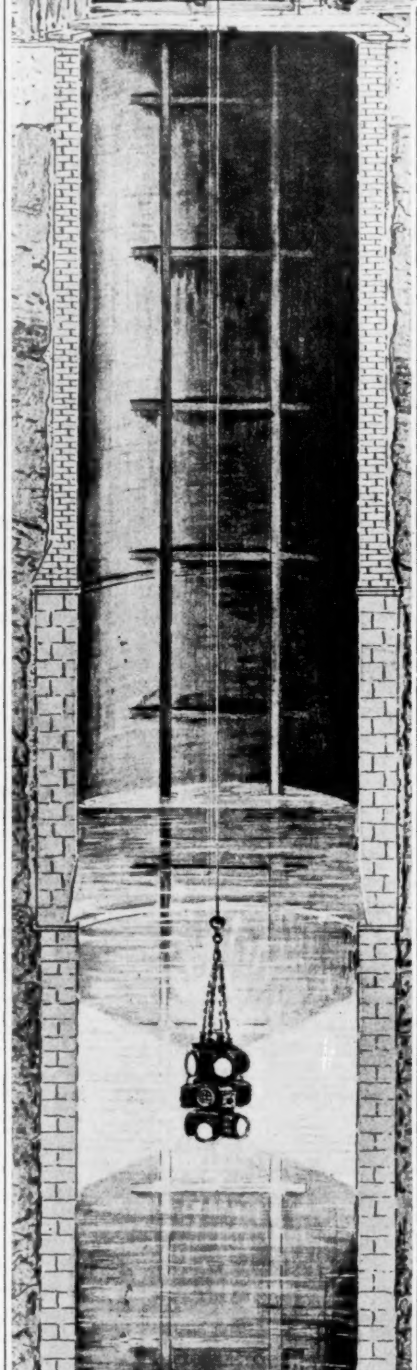


DIAGRAM SHOWING APPARATUS IN USE

Exploring with a Camera

Searching for German Traps in the Lens Coal Mines

THE deep treachery of the Germans is still bearing deadly fruit in the regions of France and Belgium that they occupied during the war. Aiming at commercial supremacy the Germans made first for the iron and coal centers of their enemies. When they were finally forced to retreat from the coal regions of Lens the Teutons realized that they must give up a rich prize which could not be carried along with them, and following their usual policy in such circumstances they proceeded to wreck the mines. Had they merely punctured the lining of the shafts and let the water from the overlying strata run in and flood the mines they would have made the mines useless to the Allies for many months to come. That would have been sufficient to serve all military purposes; for the German generals knew that they could not continue the struggle much longer and the Allies could not have put the mines into shape for use before the termination of hostilities. However it was not merely the opposing armies that the Germans were aiming at but the peace-time industries of France, and so they undertook to make the task of reclaiming the mines so difficult that they would be practically useless long after the termination of the war. Not only were the mine shafts punctured but traps were cunningly laid to blow up the divers who would be sent down to make repairs. There were several serious accidents when reconstruction work at the mines was first started, and repairs had to be suspended until some method of locating the death traps could be found.

The final solution of this knotty problem is pictured in the accompanying engravings. The French Government decided that it would be expedient to explore the mineshafts with the photographic eye of the camera before risking the lives of divers in these perilous shafts. The problem was complicated by the fact that the camera would have to take its pictures under water. However submarine photography is not a new art and it was merely necessary to design a special photographic outfit to meet the peculiar requirements of the Lens district.

A commission for such an outfit was given to Messrs. Siebe, Gorman and Co., the well-known submarine engineers of London, and they built the apparatus that is depicted on the opposite page. The apparatus had to carry its own lighting equipment to provide adequate illumination of the walls that were to be photographed and also a set of cameras that would make photograph records of every part of the mine shaft.

The diver alongside the apparatus in the photograph gives some idea of the huge dimensions of the outfit. It weighs complete about 1,700 pounds and measures over all 3 ft. 4 in. by 3 ft. 4 in. by 4 ft. 9 in. high. It is composed of three main gun-metal castings bolted together. The cameras are located in the middle section while the lamps are situated in the upper and the lower castings. Each of the latter castings is divided into four water-tight chambers and each chamber contains a mercury vapor lamp. The lamps are of 3,000 candle-power giving therefore a total light of 24,000 candle-power. The middle casting is partitioned off to form eight chambers; four larger ones in which the lamp resistances are located and four smaller chambers in which the cameras are placed.

The mercury vapor lamps are of the quartz tube type and each has an over-all length of nine inches. They are operated in parallel on a direct current supply of 200 volts with a current consumption of 3½ amperes. The lamps are tilted to start them by means of special levers actuated by rods on the outside of the chamber.

The cameras employed in the apparatus are of a special box type. Because of the narrow quarters in which they are to operate they are fitted with very wide angle lenses. The shutters are controlled by means of electricity.

With this huge photographic apparatus the lining of flooded mine shafts will be thoroughly explored. The photographs will be pieced together and examined minutely for any signs of German treachery. If any traps are located or any suspicious objects discovered they will be blown up. The exact location and character of breaks will be determined

We are indebted to the *Illustrated London News* (June 26, 1920) for the accompanying illustrations and for the details of the description given above.

AMMONIA LEAKS IN REFRIGERATING PLANTS

By B. E. HILL

TESTING for ammonia leaks is an important part of an engineer's duty. There are two principal places to test, one being in a submerged tank, where, if there is a leak in the coils, water cooler or any liquid, the ammonia will be absorbed. If the liquid is of great volume there will be a considerable quantity of ammonia taken up before the engineer or attendant can detect the odor.

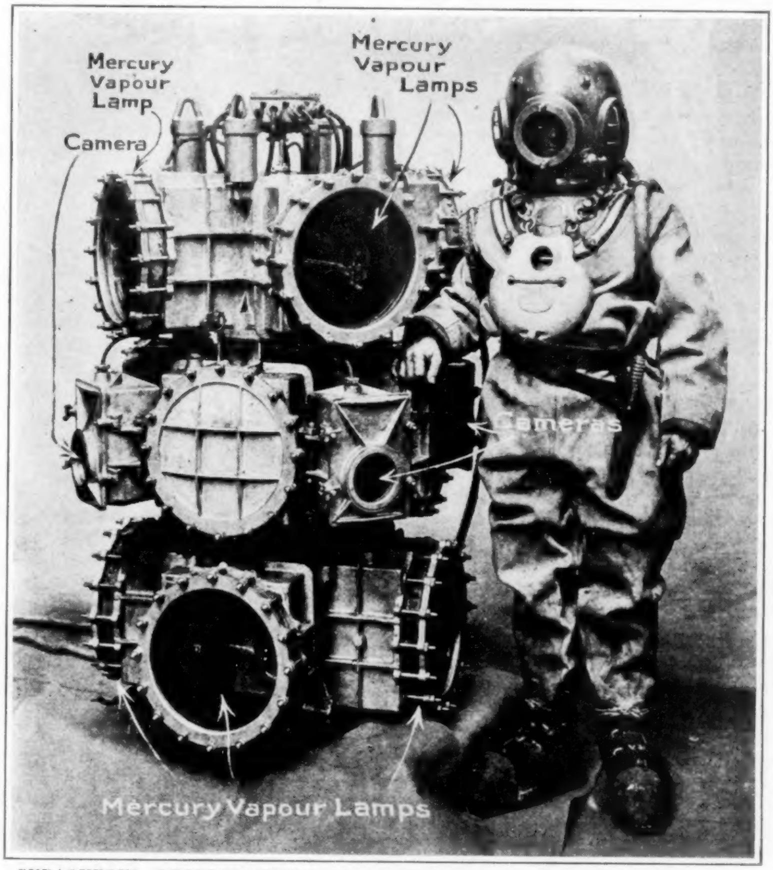
To test the brine or other liquid for a leak, get a sample of brine in a drinking glass and put in a drop or two of the phenolphthalein. If there is the least trace of ammonia, the phenolphthalein will cause the brine sample to turn a faint pink, and if there is enough ammonia to be detected slightly by smell, the sample will turn a deep red.

The next test is for leaks in the open air, and as the sulphur stick is the most popular, effective and practical, we will consider where it can be used and where not.

To prepare the sulphur stick melt five or ten pounds of either powdered or lump sulphur in a ladle with a very slow fire. A slow fire is necessary as the sulphur fires at a low temperature and, if too hot, will become lumpy and thick and will run off and drip when used. When the sulphur is at the right temperature it will be thin like water. Now the sticks should be prepared by splitting up a hundred or so pine strips, cardboard or other material and dipping both ends in the sulphur, which quickly cools; the sticks are now ready for use. To apply the sticks, take a handful and light one, and before one burns out another can be lighted from the one in use.

Any coil that has just been erected or overhauled should first be tested with air pressure, after which the joints should be brushed with soapy water. After all leaks found in this way have been stopped, pump out the air until the vacuum gage shows as high a vacuum as can be had. If it is found that the air is still discharging through the discharge bypass, keep on pumping till the air is hardly perceptible. This extra precaution is taken to make sure that the air is as nearly all out as can be pumped with the machine; also, there is always a chance that the vacuum gage may not be correct.

After the air has been pumped out the ammonia should be charged into the coil at once and the final test made with the burning sulphur held under and over all joints and connections. If there is a leak at all, it will be shown by a gray smoke wherever the sulphur and ammonia fumes come together. The sulphur fumes are as effective in showing a leak in the open air as the phenolphthalein is for showing one in the brine tank; as, for example, where there is a leak in a thread or joint that is so small that it will not be noticed with the soap bubbles and is difficult to detect by smell after the leak is found, the sulphur will mark the leak by leaving a small yellowish white spot, even though the leak is no larger than a pin point.



SUBAQUEOUS PHOTOGRAPHING APPARATUS BUILT FOR EXPLORING THE COAL MINES OF THE LENS DISTRICT

Leaks on return bends of atmospheric condensers, where the condensing water is flowing over the part that is leaking, will cause the solids in the water to accumulate to a considerable extent, which deposit will be of a whitish color. Leaks in water jackets on the compressor, if of any extent, will clarify the water, and if the fingers are dipped in it and rubbed together they will feel soapy. In this case the leak can easily be detected by smell.

In a room where the timbers or building materials of any kind are damp from moisture, the sulphur stick is almost useless, as the moisture will take up the ammonia gas and the sulphur will sometimes "smoke up" the whole room and show smoke on a post or the wall where there is no leak. In such cases is is sometimes necessary to pump the coil down to about atmosphere on the gage and open the room so that a circulation of air will drive the ammonia out of the room before the leak can be found.—Reprinted from *Power*, June 15, 1920.

MINING IN GERMAN SOUTH-WEST AFRICA

COPPER ranks next to diamonds in the minerals of the Protectorate of South-West Africa, and, unlike diamonds, it seems to be establishing itself as an increasingly productive industry. The chief deposits are in the dolomite rocks of the Otavi district, which is connected with Swakopmund by rail. About a quarter of the line is of Cape gage, the remainder of a 2-foot gage. Other copper areas are Khan and Ida in the Swakopmund, and Sinclair in the Luduitzbucht districts. In 1913 the exports of copper and copper ore were valued at £396,000.—*Indian Engineering*, April 3, 1920.

Science and National Progress

Edited by a Committee of the National Research Council

Dr. Vernon Kellogg, Chairman, Dr. R. M. Yerkes, H. E. Howe

INSTITUTE FOR PLANT PROTECTION

By H. H. Whetzel,

Professor of Plant Pathology, New York State College of Agriculture at Cornell University, Ithaca, New York.

The National Research Council is a coöperative organization of the scientific men of America. It is established under the auspices of the National Academy of Sciences and its membership is largely composed of appointed representatives of the major scientific and technical societies of the country. Its purposes are the promotion of scientific research and of the application and dissemination of scientific knowledge for the benefit of the national strength and well-being.

THE need for conserving human and animal life by developing methods of protection from diseases and pests is now generally recognized and institutes, hospitals and organizations innumerable are supported by both governmental and private funds for this purpose. It is much less generally understood, in fact scarcely realized by the great mass of people that the protection of plants from pests and diseases is equally, if not more important, than the like protection of man and animal; that the very existence of human and animal life depends upon adequate plant production. Plants constitute the raw materials for all food and clothing and much of our shelter—the three fundamental requirements of living. Conservation and increase of human and animal population require, in fact demand, conservation of plants.

The most serious leaks in crop production today are those occasioned by diseases and pests. No plant that grows, be it wild or cultivated, is without its peculiar diseases and insect pests. Cultivated plants, because of the conditions under which they are grown, suffer especially. Often these diseases and pests bring national catastrophe. Ireland suffered a terrible famine in 1845 through the destruction of her potato crop by blight, and this disease still wipes out literally millions of bushels of potatoes every year.

The chestnut blight starting on Long Island in 1906 and sweeping westward destroyed or doomed all our chestnut timber. The white pine blister rust threatens our greatest timber crop. The gypsy moth and the brown tail moth devastate great areas of New England forests and orchards each year and the States and Federal Government spend annually hundreds of thousands of dollars in attempts to stay their progress. The European corn borer has established itself within our borders and threatens one of our most important staple crops with terrible destruction. But the constant and usual drain upon our plant resources by endemic pathogenes is even more alarming. For every two sweet potatoes we buy, we pay for a third one destroyed by disease in field or storage house. Every time we purchase six cotton shirts we pay for a seventh lost to disease in the cotton fields of the South. We complain of war taxes, but do not even know of the immensely more useless and enormous plant disease tax which we daily meet and pay as a matter of course.

Consider our chief bread crop, wheat. In 1918 we harvested over nine hundred million bushels, but lost to five diseases alone over thirty-three million bushels, approximately one bushel out of every thirty. Everybody eats potatoes. They are one of our chief staple foods. Yet last season we lost through diseases in this crop one bushel to every five saved. Think of it, one-sixth of our crop! A like proportion of our beans perished. For every two bushels of tomatoes harvested another bushel was left in the field a victim of disease, adding a third to the cost of tomatoes to the consumer. But in addition many tomatoes perished from disease in transportation and in the markets. It is safe to say that nearly another third thus fell by the wayside. In other words, the consumer paid double what he should for every bushel of tomatoes he purchased and no one profited thereby, not even the much blamed middleman. Do you eat apples? Then contemplate the fact that one in every ten of the 1918 crop was taken as toll to disease, not to count those that were destroyed by bugs and worms.

What an enormous tax upon our food resources each year! And the consumer alone foots the bill. Farmers as a class do not lose, for what one farmer loses another gains in increased prices.

Upon three classes of our people lies the direct responsibility for preventing these losses, the farmer, the manufacturer of materials and apparatus, and the scientific workers in plant pathology and entomology. But effective work on their part demands the intelligent interest and financial support of the great consuming public. The farmer is rapidly realizing his responsibility in the matter and is prepared to do his part if only the requisite knowledge of methods to combat the insects and disease-producing organisms is forthcoming, and effective materials and machinery are made available at a reasonable cost. Plant pathologists and entomologists in experiment stations and colleges of agriculture are working earnestly to meet their obligations in the matter. Manufacturers are working feverishly in the production of poisons, sprays and machinery to meet the increasing demands and the new problems that press upon them. Prior to the great war the plant pathologists and the entomologists in the several States and the Federal Departments worked more or less independently on their problems. The manufacturers, influenced largely by the stress of competition, worked chiefly each to himself.

Daily during the war, the need for team work among these workers was emphasized. The plant pathologists organized their War Emergency Board to correlate and coördinate their efforts in the solution of pressing problems in plant disease control. In a single year they accomplished on certain problems what it would have taken years to do under the old regime of individual effort. The entomologists effected a similar coöperative procedure. The manufacturers felt the pressure for coöperative undertaking and began to seek ways and means of accomplishing it.

This feeling of the necessity for united attack upon the problems of disease and insect control has recently crystallized in an initial effort to bring together scientific workers and manufacturers in a real coöperative undertaking. With the advice and assistance of the National Research Council representatives of the plant pathologists, economic entomologists, and manufacturers were brought together at Rochester, N. Y., on June 23, 1920, and preliminary steps were taken for the organization of a National Plant Protection Institute. The purpose of this proposed institute is to promote the general welfare by supporting and directing scientific research on the diseases and pests of crops, shade and forest trees, and ornamental plants and on the methods of their control. Also by furthering coöperation between scientific investigators and the manufacturers of chemicals and appliances, and to bring

about standardization and economy in the production and use of means for combatting diseases and pests.

A tentative plan of organization was agreed upon. A committee on permanent organization was appointed, consisting of two plant pathologists, two entomologists and four manufacturers. Mr. G. R. Cushman, of the General Chemical Company of New York, is chairman. This committee, working with the division of Research Extension of the National Research Council, is to prepare a complete draft of the articles of association to be presented some time this autumn to a general meeting on organization representatives of all the commercial manufacturers, the American Phytopathological Society, and the Association of Economic Entomologists.

It is proposed to have two classes of membership in this association: scientific and industrial. Scientific membership to be open to members of the two above-named scientific societies and such other persons as the board of trustees may elect; industrial membership to be open to all firms manufacturing fungicides, insecticides or related materials and apparatus for applying the same. The board of trustees is to consist of eleven members, three to be chosen by the American Phytopathological Society, three by the American Association of Economic Entomologists and five to be chosen by the manufacturers. It is planned that the board of trustees may be enlarged, provided always that the majority shall be from the scientific membership.

A director, together with such staff as may be required, is to be employed by the Board of Trustees, the director to be responsible for the scientific work of the organization.

The scientific membership is to be responsible for conducting the scientific work and the industrial membership for the financial support required. All levies of funds for investigational work must have the approval of the Board of Trustees and a majority of the industrial members concerned.

Any member of the institute may suggest problems for investigation to the Board of Trustees, who shall determine what program of work is to be undertaken. The results of work supported by the industrial membership at large is to be available through publication to all members of the institute. Special investigations may be conducted for any one for his sole benefit at cost upon approval of the Board.

This new institute is to be a distinctly coöperative undertaking. Its very success depends upon effective coöperation and coördination among the three distinct groups of workers. The successful consummation of this organization and the establishment of a working institute of this type will represent real progress in coöperative public service between scientific professionals and industry.

Notes on Science in America

Abstracts of Current Literature

Prepared by Edward Gleason Spaulding, Professor of Philosophy, Princeton University

WEATHER FORECASTS BY SOLAR RADIATION OBSERVATIONS.

In the Journal of the Washington Academy of Sciences for April 19, Mr. C. F. Abbot of the Smithsonian Institution gives an account of solar radiation observations that have been employed for more than a year now by Mr. H. H. Clayton of the Meteorological Service of Argentina, as a means of making weather forecasts. Mr. Clayton has maintained for years an impartial quantitative methematical record of both the success and failure of the Argentine official weather forecasts, and states that this record showed marked and considerable gain in forecasting from the time of the introduction of this new element.

This new departure rests on the fact that our sun is a variable star. This result was reached by the Smithsonian Institution in its investigations of the intensity of solar radiation. For nearly 15 years the Smithsonian Astrophysical Observatory has maintained a solar radiation observing station at Mount Wilson, California. This station is usually occupied from May to November. Its main investigation comprises spectrobolometric determinations of the so-called "solar constant of radiation" after the general method of Langley.

Early results indicated that this quantity is not really a constant, but varies over a range of several per cent, both from year to year and in short irregular period of days or weeks. Confirmation of these results has been secured in many ways, so that now there remains but one possible explanation of the phenomenon other than that the sun itself varies in its emission by several per cent from time to time. This alternative possibility is that atmospheric changes occur simultaneously over the whole earth which lead to variable erroneous determinations of the so-called "solar constant," and that the errors thus produced are nearly equal and introduce apparent variations in the same sense, however far apart the two simultaneously observing stations may be. Mr. Abbot believes it is easier to admit that the sun itself is variable as supposed. Other irregularly variable stars are numerous. There is no reason why the sun, too, may not be variable. One of the most convincing proofs of the essential soundness of the measurements which indicate solar variability comes from Clayton's investigations of terrestrial temperatures.

Clayton found that coefficients of correlation ranging from $+ 0.54$ to $- 0.50$ occurred as between solar and temperature changes. His studies covered not only the day of the solar observation itself, but the five days next following. He found that the largest temperature effects occurred generally from the third to the fifth day after the solar event.

These early results of Clayton's seemed so interesting and promising that the Smithsonian Institution established a new solar radiation observing station at Calama, Chile. In the meantime, Mr. Clayton and his colleagues in Argentina have diligently continued their computations on the terrestrial effects produced by solar variations. The results they reached, up to June, 1919, have just been published by the Smithsonian Institution.

Clayton carries on the study of what happens after a change in solar radiation for many days, sometimes even 40 days after the event. This leads to the surprising result that the largest effects come not three days, but even 10 days and 17 days after. Perhaps equally or more important in Argentina, where there is hardly adequate rainfall, are Clayton's results on the dependence of precipitation on solar radiation, if confirmed. He finds that heavy rains are apt to occur from three to five days after large decreases of the solar radiation. At times of nearly stationary solar intensities, there seems to be practically no precipitation. In a few instances precipitation follows large increases of radiation. But almost universally great decreases of solar radiation are followed in from three to five days by heavy precipitation. Such information is of great value for vineyard growers and agriculturists in other lines if it proves to be well founded.

In December, 1918, Clayton began to employ the results furnished by the Smithsonian observers at Calama, Chile, for actual forecasting. Fully convinced of the value of such data, Prof. C. C. Wiggins, Chief of the Argentina Weather Service, arranged for a daily telegraphic service from Calama to Buenos Aires and Messrs. Moore and Abbot the Smith-

sonian observers at Calama, completely reduced the "solar constant" value on each day of observation. They send a code telegram from Calama via Antofagasta and Valparaiso, Chile, to Buenos Aires on the evening of each observing day. This states the intensity of solar radiation outside our atmosphere, and the quality of the determination. The value is available in Buenos Aires for the forecasting on the following morning, within 24 hours of the time of observation.

During his visit to Calama in June, 1919, with the coöperation of the observer there, Mr. Abbot was able to perfect a new empirical method of "solar constant" determination, based upon data obtained by Langley's methods. The new method of "solar constant" determination is based on the fact that the atmospheric transparency varies in an opposite sense to the variations of the brightness of the sky. Increased haziness means more reflecting surface to scatter the solar rays indirectly to the earth. At the same time it means more obstructing surface to cut off the direct solar beam. It has been found accordingly that, from measurements of the brightness of the sky near the sun, it is possible to infer the atmosphere transmission coefficients at all wave length. In this new process all the observations can be made in 15 minutes, and the "solar constant" value can be completely worked out in a couple of hours.

In recent letters Mr. Clayton states that his most recent studies have but increased his enthusiasm for the value of solar radiation observations in forecasting. By means of curves he shows a striking direct correspondence between the temperature departure for Buenos Aires and other South American cities in November and December of 1919, and the slightly antedating solar radiation changes. The direct temperature effects lag from two to three days behind the solar fluctuations.

The new means of forecasting cannot yet be regarded as either simple or fully satisfactory. Much investigation must be made before they take established rank in meteorology. Enough has been done, however, to show that there is promise. Before the promise can come to fruition continuous daily records of well determined solar constant values are necessary. These cannot be secured with the means now available. The solar radiation station at Mount Wilson is not occupied more than six months per year, and never yields more than 130 values of the "solar constant" in that period. Of these not all are good. The station at Calama yields about 250 good values per annum now that the new method of observing is adopted. These are the only stations of the kind in the world. There should be two or three others, widely separated in the most cloudless regions available, such as Egypt, Southern California and Middle Australia.

Since the accuracy of the determinations of the solar variations would be enhanced by uniformity in the methods of observing, it is quite desirable that the measurements at the several stations should be made under a common control and direction.

The methods of observing and reducing have been devised and perfected at the Smithsonian Institution, but they would very willingly be communicated to any international organization which was prepared to take up measurements of the "solar constant." On the other hand, if the Smithsonian Institution had the means, preferably $1,000,000 to devote to the subject, it would be practical for the Institution to carry on "solar constant" determinations in perpetuity in such a manner as to afford a satisfactory groundwork for any application to them which meteorologists may wish to make hereafter.

EDUCATION IN SCIENCE BY "THE MOVIES"

ACCORDING to *The Social Hygiene Bulletin* for May, 1920, the utilization of moving pictures in the public schools is already an established fact and will become increasingly important. The Society for Visual Education was recently organized for the development of this field. The Society is incorporated under the laws of the State of Illinois and is now engaged in producing approved films whose distribution will begin September 1, 1920. Scenarios are prepared by committees of educational experts on the various subjects.

The Society has produced a projecting machine especially adapted to the use of schools; it publishes a monthly journal, *Visual Education;* and its activities are supervised by a board of directors and a general advisory board composed of many of the foremost educators of the country. Its films, according to a statement in the first issue of *Visual Education*, are to be used directly in the classroom; they deal with the fundamental school subjects, and are carefully articulated with the curriculum; they present the normal and important things, rather than the exceptional and bizarre; they are based on sound principles of teaching, and are intended to give meaning and life to isolated facts. The films prepared under the direction of the committees on health and on biology will be correlated with modern principles of sex education.

Intense interest in visual education was shown at the annual convention of the National Education Association held recently in Cleveland. For the first time in the history of the Association, a department of visual education was established as an official section of the Department of Superintendence, and an afternoon's program was devoted to the subject. Following this, an informal conference was held, as a result of which a committee of nine educators, in no way connected with commercial film organizations, was appointed for the purpose of calling a representative conference on the subject and of perfecting a permanent organization. Several important educational films were shown during the convention sessions, including "How Life Begins." The Society for Visual Education was represented by an exhibit and many commercial companies also had exhibits.

THE HUMAN SEX RATIO

To the Proceedings of the National Academy of Sciences for July Mr. C. C. Little, of the Carnegie Institution, Cold Spring Harbor, contributes an interesting article on "The Human Sex Ratio." From data collected at the Sloane Maternity Hospital in New York City, it has recently been shown that there is a significantly higher male sex ratio at birth among progeny whose parents are not of similar nationality. This result confirmed a paper published by the Pearls in 1908, based on data derived from vital statistics of the city of Buenos Aires, and had in addition a decreased source of error due to improved methods of recording the data and the inclusion of still births as well as living births in the calculations.

During the past year a further study of the same records has been made concrning the sex ratio among the progeny of certain other types of matings, and a preliminary attempt at analysis made by contrasting the sex ratios of the offspring of *primipara* with those of subsequent births.

Mr. Little shows in a table the sex ratios of five categories of matings: European "pure," European "hybrid," United States white, British West Indies colored, and United States colored. European pure are matings in which both parents were of the same nationality. European hybrids are offspring whose parents are of different nationality, United States white include a random sample of parents coming from various parts of the United States but preponderantly from the East and especially from New York State and New York City. British West Indies colored are offspring from colored parents born in the British West Indies, and United States colored are offspring from colored parents born anywhere in the United States.

In each case the probable error of the ratio obtained has been calculated for the numbers observed. On the basis of these probable errors the differences between the various ratios can be fairly compared with respect to their probable significance.

The results show that there is a significant difference between the European "pure" and the European "hybrid" and

between the former and the United States white, but that there is no significant difference between the European "hybrid" and the United States white. This shows that, in the data studied, the United States white ratio is essentially that of a hybrid race.

This behavior of the United States matings is not in the least surprising, for the number of different racial stocks involved in the production of the parents of the offspring recorded is undoubtedly large.

The British West Indies colored stock, while far from pure, is obviously more nearly so than the United States colored. This is true because of the fact that the United States colored in addition to including offspring whose grandparents were born in the United States, also admits the chance that part of the grandparents may have been themselves British West Indies stock, thus adding the hereditary variations of this stock to that of the United States colored stock. It is interesting to note that the ratio of the B. W. I. stock does not depart significantly from that of the European pure whites. On the other hand, the United States colored differs significantly from both B. W. I. colored and from European pure and United States whites.

Accordingly Mr. Little divides the matings into two main groups—(1) the European pure and the B. W. I. colored as being relatively "pure," and (2) the European hybrid, United States white, and United States colored as being relatively "hybrid," and in a table examines the nature of the ratios when the progeny of *primipara* are separated from other births.

This table shows that while three hybrid matings disclose a not significant difference between the sex ratio of offspring of *primipara* and those of subsequent births, there is on the other hand a marked significance in the case of European pure matings and a barely possible significant difference in the B. W. I. colored. The entire excess of male births in the total sex ratio of 104.54 in the European pure matings is found in the offspring of *primipara* where 115.51 ± 1.50 males to 100 females are found.

The author draws the following conclusions as regards material in the records of the Sloane Maternity Hospital of New York City:

(1) Hybrid white matings give a significant *excess of males* over "pure" white matings.

(2) Hybrid colored matings give a significant *excess of females* over relatively "pure" colored matings.

(3) The sex ratios of the United States white births recorded is not significantly different from that of *hybrid* European matings.

Research Work of the United States Bureau of Standards

Notes Specially Prepared for the SCIENTIFIC AMERICAN MONTHLY

COOPERATION BEWTEEN THE BUREAU OF STANDARDS AND THE AMERICAN RADIO RELAY LEAGUE IN A STUDY OF THE FADING OF RADIO SIGNALS

THE study of various phenomena in connection with radio transmission of necessity requires the coöperation of a number of receiving and sending stations located at considerable distances from one another. The radio Laboratory of the Bureau of Standards can only conduct certain investigations with the help of other laboratories engaged in radio work.

It has been particularly fortunate in securing the active assistance of many of the foremost radio amateur operators and has recently entered into an arrangement with the American Radio Relay League by which a thorough study will be made of the fading of radio signals, a peculiarity attending this form of electrical transmission which has been observed by many operators. For some time it has been noted that the strength of a signal sent out from a given transmitting station will vary rapidly in intensity during very short intervals of time, probably depending upon the weather and various meteorological conditions. Through the efforts of the Bureau and the American Radio Relay League an arrangement has been affected whereby six well-equipped amateur radio transmitting stations will send out a broadcast message lasting for about three minutes on Tuesday, Thursday and Saturday evenings beginning just after the time signals of the Arlington Naval Radio Station, these messages to be received by about 40 amateur receiving stations. Three or four of the transmitting stations will be within the range of each receiving station and the former will transmit for their different regions 10 minutes apart.

The Bureau has provided forms on which the operators will record the strength of the signals which they receive together with other information, such as weather conditions, presence of strays or other atmospheric disturbances, and the general character of radio transmission at the time of each observation. As a result of this program of careful observations at a number of points, it is hoped that some valuable conclusions regarding radio transmission will be worked out, and if such proves to be the case, the present plan which only covers territory in the northeastern part of the United States will be extended to cover a much larger area during the winter of 1920-21.

EXPLANATION OF THE PRINCIPLES UNDERLYING RADIO TELEGRAPHY AND TELEPHONY

THERE is probably no scientific subject which has been given the amount of attention by the general public that radio communication has received, and yet some of the comparatively simple underlying principles are certainly not very generally appreciated. It is true that our whole theory of electrical transmission, including radio, is based upon certain assumptions, but it is nevertheless a fact that a great many of the fundamental principles of radio transmission are very well understood and are known to be the logical effects following the given causes. The articles frequently published in non-technical journals have surrounded the subject with an air of mystery and for this reason the Bureau of Standards believed that a simple explanation of the fundamentals of wireless communication would be well received by many people. With this object in view, a lecture was prepared and delivered at the Bureau during the past month. The wave form of radio transmission was explained and the methods by which this motion is set up by the transmitting apparatus and received by a distant station was analyzed in a simple manner. Radio waves, while similar to light and sound waves, possess very different properties from them in some respects. For instance, the wireless vibrations are at a different frequency from light waves and will penetrate buildings and many substances which are opaque to the latter. It has, perhaps, been generally supposed by the public that these waves follow around the surface of the earth, but it has been proven that they are not limited in this respect as communication may be established between an airplane and a submerged submarine. Most people likewise picture the radio sending station as equipped with antennas

strung from high poles. While it is true that this is the general type of structure for ordinary stations, the antennas may take the form of small wire coils that can be used inside of ordinary rooms or other confined spaces.

The lecture likewise described the rapid progress that has recently been made in developing sensitive instruments known as amplifiers by means of which the intensity of the waves at a receiving station can be increased. By the employment of these instruments, very feeble signals can be multiplied so as to be distinctly heard. Copies of the above lecture may be obtained through the Radio Laboratory of the Bureau of Standards.

RADIO MUSIC

IT has been well known for some years that by placing a form of telephone transmitter in a concert hall or at any point where music is being played the sound may be carried over telephone wires to an ordinary telephone receiver at a distant point, thus enabling those several miles away to listen to the music. Such systems have been in use in London between a number of the theaters and hotels for many years, but it is only recently that a method of transmitting music by radio has been found possible.

It has now been discovered that music can be transmitted by wireless in the same manner as speech or code signals and as a result of research work on radio telephony at the Bureau of Standards it has been proven that music sent by this means does not lose its quality. It is, therefore, obvious that music can be performed at any place, radiated into the air through an ordinary radio transmitting set and received at any other place, even though hundreds of miles away. The music received can be made as loud as desired by suitable operation of the receiving apparatus. The result is perhaps not so very different from that secured by means of the ordinary telephone apparatus above mentioned, but the system is far simpler and does not require the use of any intermediate circuit. The entire feasibility of centralized concerts has been demonstrated and in fact such concerts are now being sent out by a number of persons and institutions. Experimental concerts are at present being conducted every Friday evening from 8:30 to 11:00 by the Radio Laboratory of the Bureau of Standards. The wave length used is 500 meters. This music can be heard by any one in the territory near the District of Columbia having a simple amateur receiving outfit. The possibilities of such centralized radio concerts are great and extremely interesting. One simple means of producing music for radio transmission is to play a phonograph into the radio transmitter. An interesting improvement upon this method is being utilized in the experiments at the Bureau. The carbon microphone, which is the mouthpiece of an ordinary telephone, is mounted on the phonograph in place of the usual vibrating diaphragm. As a result the phonograph record produces direct variations of electric current in the telephone apparatus instead of producing sound; thus while the music is not audible at the place where the phonograph record is being played, it is distinctly heard at the different receiving stations.

THE EFFICIENCY OF INSULATION FOR COLD STORAGE WORK

THE cold storage industry is one of vital importance in this country, and the use of highly efficient insulation for such work is, therefore, imperative. During the last few years there has been a great demand for accurate information concerning the relative values of various materials that are used for insulating purposes and this has led to extensive experimental investigations in different laboratories.

While a great many factors, such as resistance to moisture, inflammability, strength, durability, etc., must be considered in choosing an insulating material, it must primarily be a good insulator and the measurement of its thermal conductivity is, therefore, the matter of greatest importance. The Bureau has developed and used for several years a very satisfactory apparatus for measuring thermal conductivity. The results obtained have been assembled and a standardized form of the apparatus suitable for general use has been designed.

The American Society of Refrigerating Engineers has taken an active interest in this work so that a standard apparatus may be available, the use of which will eliminate disputes due to differences resulting from the employment of unsuitable testing methods. Some of these discrepancies were due to technical difficulties and it may be stated that many of these have been largely overcome, but a considerable amount of educational work is still necessary among the manufacturers of insulating materials and the users of the same in order to eliminate misunderstandings. The results of the Bureau's work will be published in a forthcoming number of the Journal of the American Society of Refrigerating Engineers.

THE USE OF WET AND DRY SAND FOR CONCRETE

DURING the past month, several series of tests of concretes made from Potomac River sand and gravel have been carried out, using various proportions of cement to aggregate from 1:1-½:3 to 1:3:6 and with the extremes of flowability used in practical concrete construction work. The results of these tests emphasize a feature of considerable importance to the contractor. When aggregates are proportioned by volume measure, as is customary on most constructional work, it is found that the use of wet aggregates requires from ½ to 1 bag more cement per cubic yard of concrete than do dry aggregates. Sand is generally wet or at least moist when used, so that the full difference may never be apparent in field practice, yet the use of sand from a pile which has just been exposed to rain will result in the employment of more cement for a given volume of concrete than would have been the case had the work been done on a dry day. The excess strength resulting from the increase in cement is unnecessary, providing that designed strengths were obtained with the drier materials. As above mentioned, this increased quantity of cement may be as high as one bag per cubic yard of concrete, and the increase in strength, due to the added cement in a cubic yard of concrete made with wet aggregates is roughly proportional to the increase in cement. Therefore, if there is a marked increase at any time in the moisture carried by the sand, the tendency on the job should be to use larger volumes of sand in the batch.

Marked improvement in the working qualities of the concrete will be noted under usual conditions when the relative volume of sand is increased and the gravel proportionately reduced. With well graded river sand and gravel, such as is available in the District of Columbia, the "oversanding" may be beneficial up to the point where the volume of sand in the batch is equal to the volume of the gravel. Such concrete will not segregate for maximum flowability commonly used in construction work; it will be easier working, the quantity of cement required per cubic yard will be slightly less and there will be no reduction in compressive strength.

DURABILITY OF CONCRETE IN ALKALI SOILS AND WATERS

THE investigation which the Bureau has resumed after a lapse of 3 years, due to the war, on the durability of concrete in akali soils and waters, has been previously mentioned. Tests made during the past year tend to confirm the conclusions, as previously stated in Technologic Paper No. 95; but final conclusions, as to the resistance of concrete to the action of various types of alkali waters cannot yet be drawn from the data now on hand. One interesting point, however, which has been definitely brought out by this work, is the marked variation in concentration of salts which may be

found in the soil short distances apart. Tile placed in the highly concentrated portions or receiving seepage water direct from such areas may be exposed to concentration several times as great as similar tile which may happen to be placed further down the drain. The highest concentration of seepage water is not made apparent by analyzing the water collected at the outlet of the drain. Analysis of samples of soils, and borings distributed over a tract of land previous to installing a drainage system may give a fairly good idea of the type of salts and the average concentration to which the tile later may be exposed, but there is no assurance that in small localized areas much higher concentration may not be found, or may not develop through a change in drainage conditions. As a type, sulphate waters appear to be most destructive to concrete, the severity of action seeming to vary with concentration of soluble salts. The wide variation in quantities of the various constituents found indicates that action is not greatly dependent upon the presence or absence of any one constituent of water in which a large quantity of the sulphate is present.

Progress in the Field of Applied Chemistry

Notes Culled from Current Technical Literature

By H. E. Howe, Member of American Chemical Society

BLEACHING SILK

THE May number of *Dyestuffs* quotes J. L. Girard on the subject of bleaching silk, the original article having appeared in *Textiles*. When silk has passed through the boiling-off process, which removes most of the natural gum, it is of a cream shade, and before it can be satisfactorily used in dyeing or when used undyed, the cream shade is removed as far as possible by a bleaching process. This is quite similar to the process used in bleaching wool, and the first method is based on the action of sulphurous acid gas. This is a well-known and long established method which gives satisfactory and reliable results and is economic in operation. The silk is subjected to several exposures to the gas in a closed chamber, and the materials which give rise to the color are reduced by the action of the gas and washed out of the fiber between successive exposures to the sulphurous acid gas. It is indispensable that the silk be kept uniformly moist. Some sulphuric acid vapor is formed, and it is essential that the silk be prevented from becoming dry while in the chamber if no serious effects upon the fiber are to result. The air in the special chambers is therefore kept saturated with moisture. This moisture, however, must not be present as drops of water, and any moisture which collects in drops is carried away by the roof and walls of the chamber specially designed for this purpose.

Care is exercised in sweeping the gas out of the chamber when it is to be removed, since the gas must be taken out at a uniform rate from all parts of the room if uniformity in the color and condition of the fiber is to be expected.

The more recent method of bleaching is based on the oxidizing action of peroxide, particularly peroxide of hydrogen, and in certain instances both the peroxide and the sulphur process are used in combination. This combined method gives the best results.

UTILIZATION AND WASTE PREVENTION IN LUMBER

THE National Lumber Manufacturers Association is doing a valuable work through its Committee on Utilization and Waste Prevention, which is conducting research on a large scale which should yield results of benefit to the public at large. A diagram issued by the committee indicates the points at which waste might be prevented, as well as the agencies through which to accomplish this result, and indicates further some of the ways in which unavoidable waste may be utilized.

A large amount of waste results when timber is sawn, a strip ⅜ inch wide being reduced to sawdust by the best of the saws now in use. The committee is coöperating with saw manufacturers in the design and development of new types of saws, which may reduce the width of the cut. This in turn calls in the chemist and the metallurgist to prepare special materials from which thinner saws can be safely made and involves engineering in the development of improved designs.

Another very useful piece of research is being conducted in coöperation with the Underwriters Laboratory where 12 by 12 columns have been subjected to full compression loads under temperatures as high as 1,800°F., to determine the behavior of such columns as are found in mill construction. It is surprising to find that timber of this sort, under 100,000 pounds load functions for six times as long as hollow steel or cast iron columns, sometimes used. In fact the column of wood usually fails because of the failure of the iron cap used upon it, and the committee through its engineers has designed and patented an improved type of cap capable of rendering service under the extreme conditions of fire for a time equal to the life of the column itself.

The Association coöperates with the various government and other laboratories interested in its problems and through its research is now endeavoring to obtain data which we should have had these last twenty years.

BETTER CANNING

IN the June number of the *Journal of Industrial and Engineering Chemistry* an announcement is made that the Glass Container Association proposes to give prizes to any students working for a degree in college or university, for the best suggestions for various ways of safer canning and the use of more convenient glass receptacles for canned food. The Glass Container Associations research program is an outgrowth of prohibition which deprived a number of bottle manufacturers of a large share of their profitable business. They now turn to science to aid them in finding ways to continue the profitable manufacture of glass containers. The contest announced carries with it awards of from fifty to one hundred and fifty dollars, and the results of the research investigations are to be announced in essays along lines of the better preparation and packing of foods for canning purposes with particular reference to the use of glass.

CLEANING METAL SHEETS

IN the *Iron Trade Review*, R. R. Danielson discusses the preparation of sheets for enameling where the necessity for cleanliness is important. During forming operations the metal to be enameled is certain to receive a covering of grease and oil, which if allowed to remain are sure to cause trouble. Previously a process called "scaling" was employed, in which the ware is heated in a muffle furnace for a few minutes, so that a light scale which will easily separate from the metal is formed. This has its advantages, but is apt to cause warping, especially with large sheets. Oxide is also liable to form, and its removal means more time in the pickling bath. Chemical cleaners have therefore come to be used. There are a variety of these offered, including those composed of sodium hydroxide, sodium carbonate, ammonium carbonate, borax, tri-sodium phosphate, sodium silicate, resin soaps and soaps of other

types. Sometimes gasoline is employed to dissolve this oil film.

It is necessary, when using chemical cleaners, to keep the bath near the boiling point, and care must be taken to separate the oil which accumulates on the bath. It has been found that an electric current will accelerate the work to an important degree because of the formation of hydrogen bubbles on the surface of the plate, and these act mechanically to carry off the grease. Some maintain that the material to be cleaned should be made the anode, this process being successfully used in one enameling plant which has entirely given up the older scaling process.

THE CONSERVATION OF FOOD ENERGY

WHILE the little book bearing this title was published in 1918 it contains in interestingly written form much information which people generally should have. Its author, Dr. H. P. Armsby, has long been identified with studies relative to animal nutrition and is probably the world's best informed individual on that subject.

As the author indicates, it does not matter how bountiful the farmers' crops have proved; they are not human food in their crude state and to prepare them for utilization involves either manufacturing processes or they may be fed directly to animals which are able to convert this raw material into a type of food which the human system can assimilate. It is important to us, therefore, to learn how we can get the greatest human food value out of a bushel of wheat or corn. Shall we feed it to live stock, and if so, to which one of the animals which are maintained because of their edible products? Or is it better to manufacture it into flour? Or shall we call in the chemist and produce starch, glucose or fermented materials, and feed the residues from these manufactured products to our live stock? Here again the type of live stock to be fed constitutes a problem for research.

The book in question supplies much data useful in our attempts to solve this problem. It gives interesting details as to how the amount of energy in human foods can be determined and the efficiency of animals from the standpoint of energy values and the recovery of energy. The food value of crude materials increased by the animal, the over-head feed cost and factors in the consideration of wheat, corn, rye and other grains, are subjects of interesting chapters.

An example of energy recovery may be taken from the case of peanuts. On the basis of 100 pounds of hulled nuts the record shows that, taking into account the recovery of energy in animal products and in oil, of which forty pounds are obtained from one hundred pounds of nuts, the following percentages of recovery can be noted:

Cattle 70%	Sheep 71%
Swine 84%	Dairy cows 85%

and when used directly as human food 93% of the gross energy is utilized. From this it would appear that it is not ordinarily economic to use peanuts as food by way of live stock, but they should be used directly as human food.

In many cases the animal performs a most important function by utilizing products inedible by man and the by-products of manufacture. Animal nutrition, therefore, is closely bound up with the problems of national nutrition and presents a field for research so broad that it may be said to have been little more than touched.

CHEMICAL READING COURSES

THE increase in interest on the part of the public in scientific literature, particularly chemistry, led the American Chemical Society to appoint a committee on the preparation of a recommended list of chemical texts for libraries. The report of this committee appeared in the July issue of the *Journal of Industrial and Engineering Chemistry*. The committee is a representative one, and in their report each of the members has contributed information with relation to some particular field of the science. The report was concluded in the August issue of the *Journal*, and those who will take the time to read it will at once be filled with a desire to acquire some of the interesting texts which are outlined in it.

The report begins with references to elementary or introductory chemistry, as intended to include books which give the facts and principles of chemistry which have been written in a way to appeal to readers who may not have made a special study of chemistry. Subheadings indicate that chemistry has its human interests, its history and biographies, and its delightful works indicating the personalities of some of the older scientists such as Dalton, Davy and Faraday. "Health in Sanitation," "Food and Nutrition," and "Economy in the Home," are other attractive subheadings. General and physical chemistry goes back to what others have done, an account of some American achievements and, of course, reference to colloids.

In inorganic and analytical chemistry additional works are given which link up with industry and which cover many special subjects. Besides all this there are lists of books on miscellaneous subjects where titles and a sentence or two of explanation should simplify work of choosing at least a few books which should represent chemistry in every library.

This work of the committee fills a real need, and chemists everywhere will hope that the reading public will not fail to make the acquaintance of the science which in their minds, at least, is quite fundamental.

HELPING THE BEES

G. V. WESTBROOKE, in the New Zealand *Journal of Agriculture*, 1920, Vol. XX, page 118, reports the results of experiments in which honeycombs were made of thin strips of aluminum shaped to resemble worker cells. The surfaces of the cells were brushed with bees wax, and the bees showed no hesitancy in building upon these coated edges. In this way the bee was saved the time of building the wax and, incidentally, the metal combs could be extracted without breakage. Even the combs containing thick honey could be extracted practically clean when higher speeds were used in the extractor. At these high speeds the aluminum did not break. Even the busy bee may thus come to appreciate the chemist and the metallurgist.

A CHEMISTRY DETECTION OF FINGER PRINTS

THE *Journal of the Franklin Institute* for June abstracts an article by C. A. Mitchell in the *Analyst* of 1920, page 122, on the detection of finger prints on documents, in which new information is given on the most suitable method for detecting latent prints, such as those on a book, and on the period of time after which it is possible to detect the marks on different qualities of paper. Photography, even with oblique illumination, is unsuccessful without some method of increasing the contrast, and this is where chemical compounds are called in. A mixture of chalk and gray powder, a form of mercury known to the pharmacist, is used on dark surfaces, while lampblack with finely powdered graphite may serve for light surfaces. Another investigator prefers ten per cent of Soudan red, a synthetic dye, in lycopodium, where highly glazed paper is concerned. Finger prints have been developed after three years with methylene blue. Highly sized papers and those with a considerable percentage of clay filler are not liable to retain impressions very well.

Osmic acid has been used successfully in some cases as a developer, basing its application upon the fact that finger prints must contain small amounts of organic matter. Consequently if a one per cent solution of osmic acid and water is brushed over the print and then is exposed to sunlight the ridges become dark. A standard ink has also been used, this being composed of osmic acid, pyrogalol and water applied with a soft brush. Iodine vapor is also a highly sensitive reagent, but prints brought out with it are difficult to photograph because the coloring is so fugitive. Mercury iodide is somewhat better. The vapor of osmic acid is another of the

reagents which has been used, being prized by some because it serves to emphasize the relations, size and other data concerning the pores which are constants that have been utilized by some investigators.

VULCANIZED FIBER

In the June 16th issue of *Chemical and Metallurgical Engineering*, L. R. W. Allison discusses vulcanized fiber in a short article. This fiber is made from cotton rag stock, which, after being cut into small pieces, is boiled with soda, washed, bleached and reduced to pulp. It is colored as may be desired and then run off on fiber machines. The resulting unsized pure fiber is passed through a bath of zinc chloride in which the surface of the sheet is gelatinized to such an extent that the various layers unite to form a homogeneous mass of any desired thickness. The sheets are now neutralized and freed from chemical reagents, dried, calendered and cured for a considerable time up to one year, depending upon thickness. Thus far no method of shortening this seasoning process has been developed to give results equal to the natural curing. This inferiority due to hastened curing may show in the shortened ultimate life of the fiber and the decrease in dielectric strength.

When tubes are to be formed the gelatinized fiber is wound on steel mandrels of a size to give the required internal diameter and with thicknesses dependent upon the number of sheets wound on. Rods are turned down from square strips on a dowel machine.

TESTING GALVANIZED COATINGS

At the annual meeting of the American Society for Testing Materials, Dr. A. S. Cushman demonstrated a new method for testing galvanized coatings, which depends upon measuring the volume of hydrogen given off when the zinc coating is destroyed by the action of hydrochloric acid. Any test should form the basis of determining the weight of coating on any part of the surface of a flat sheet or other form of galvanized metal. The test should not destroy the material under examination. It should be applicable where laboratory facilities are not available and should make possible the testing of small pieces as well as differently formed sheets of galvanized metal. Accuracy is, of course, essential.

In the method under discussion a tinned iron ring, shaped to fit the given surface, is brought into contact with the surface under test and made tight with modeling clay. Into the ring a rubber stopper is fitted, this making a cell into which a hydrochloric acid—antimony chloride mixture—can be run upon the surface through a suitable thistle tube with stopcock. The reaction, during which the hydrogen is produced, takes place very quickly—in about 30 seconds—after which the volume of hydrogen collected in a gas measuring burette is read off, and knowing the area of the spot covered by the ring, it is a simple matter to calculate the ounces of zinc per square foot of coated sheet.

By a slight modification the same method has been used in testing small pieces of coated metal, and data thus far published indicate an accuracy for the method which compares favorably with that obtained by other means.

TELESCOPE DISKS

Large telescope disks are being made in the United States and all mechanical difficulties have been overcome, according to an announcement made by Dr. George W. Morey, through the bulletin of the American Chemical Society.

The first disks from which astronomical telescope lenses were made from American optical glass were 3 or 4 inches in diameter. Recently a special 4¾-inch lens was ground for Lowell Observatory, at Flagstaff, Arizona.

The first 9½-inch disk was turned out last December. Six others have since been made and delivered. As their diameters increase, disks are made with greater difficulty. Finally, on February 15, 1920, the first perfect 12-inch disk was furnished, and a large optical glass corporation now lists this size for short-time delivery.

The next size attempted was a 20-inch disk, in the manufacture of which the problem was still more complex. Several flawless ones were produced, but they cracked in the annealing process. American ingenuity was brought into play to devise a means of slowly cooling these immense plates of glass so that they might be free from that strain so likely to destroy them. Experiments by scientists of the Geophysical Laboratory showed exactly how slowly their temperatures must be lowered, and the cooling schedule outlined was closely followed. Owing, however, to the extreme cold weather of last March and the shortage of gas, this schedule could not be followed. One splendid disk strained and broke just when nearly ready to be taken from the oven.

Equipment hitherto used was then scrapped, and an electric furnace was specially designed to meet the needs of the problem by experts of an electric company. This device is thoroughly insulated and provided with an automatic appliance which will hold the temperature absolutely constant to a fraction of a degree while the glass is being treated to remove strain. The temperature can be dropped a few degrees a week.

With the aid of this furnace now in process of construction, it is believed that the last difficulty in the way of the American manufacture of the largest disks will be overcome. Orders have already been accepted for the production of several large guaranteed disks, including one pair of the 18-inch size for refracting telescopes, and a 36-inch disk for a reflecting telescope. The furnace will receive the 40-inch size.

THE HEAT TREATMENT OF HIGH CHROMIUM STEEL

The Bureau of Standards has completed certain investigations relative to tensile properties, hardness, and micro-structure under varying thermal treatments of high chromium steel and has made a preliminary report. A summary of the results may be given as follows:

Samples of high chromium steel of the following analysis: C .29%, Mn .38%, Si .70%, Cr 13.2% quenched in oil from various temperatures show:

(a) That hardness, as measured by Brinel and Shore instruments, increases with increasing quenching temperature until a temperature of about 1,066°C. (1,950°F.) is reached. Maximum range of hardness is generally obtained by quenching from this temperature, up to the highest heat used, but in some cases this hardness actually decreases, due to retention of the solid solution.

(b) That quenching from about 955°C. (1,750°F.) develops the best combination of strength and ductility which is not coincident with range of maximum hardness. Quenching from this or lower temperatures does not retain all the carbide in solution, as is the case in samples quenched from considerably higher temperatures, notably 1,140° to 1,232°C. (2,100° and 2,250°F.).

(c) That ductility as measured by elongation and reduction is very low in those samples quenched from 1,010°C. (1,850°F.) or above.

Short-time tempering at temperatures up to about 427°C. (800°F.) of samples previously quenched from both 955° and 1,149°C. (1,750° and 2,100°F.) decreases brittleness. However, ductility is increased to a greater extent in those samples quenched from 955°C. (1,750°F.) than those quenched from the higher temperatures. Tempering above about 427°C. (800°F.) markedly decreases strength values and hardness, which is, of course, accompanied by greatly increased ductility. In general, the structure of the hardened steel tends to persist even when tempered for a short period of time at temperatures comparatively close to the lower critical range, the characteristics depending upon the quenching temperature used. The most rapid change in tensile properties and hardness occurs in tempering between about 427° and 538°C (800° and 1,000°F.).

Progress in the Field of Electricity

Summaries and Excerpts from Current Periodicals

By A. Slobod

THE RELATIVE ACTIVITY OF RADIUM AND URANIUM

THE relation of the activity of radium to the activity of the uranium with which it is in radioactive equilibrium has been experimentally redetermined. The results obtained indicate that if the activity of uranium is taken as unity the activity of the radium is equal approximately 0.49.

The total activity of uranium mixed with equilibrium quantities of its disintegration products has been compared with the activity of the uranium alone, and the former has been found to be 4.73 times the latter.

A critical examination has been made of the various theories which have been proposed to explain the genesis of radium and actinium from uranium. None of these theories appears to satisfy the necessary requirements.—J. H. L. Johnstone and B. B. Boltwood. *American Journal of Science*, July, 1920, pp. 1 to 19.

RENOVATING LECLANCHÉ POROUS POTS AND UTILIZING SPENT DRY CELLS

IT is hardly necessary to mention how widely the Leclanché as well as the dry cell have been used; of timely interest is, therefore, a paper by W. J. Thorrowgood read before the Institution of Railway Signal Engineers disclosing the possibilities of quite important economies in the use of these cells. For chemical treatment of spent Leclanché pots the author gives the following process which has been used successfully on the London and South-Western Railway.

1. A solution of commercial hydrochloric acid one part and water—five parts is to be made up and such a quantity placed in the Leclanché glass jar that, when a porous pot stands in the jar, the solution comes nearly up to the black rim at the top of the pot.
2. The pot is to remain in the acid solution for 24 hours.
3. The pot is then to be washed and soaked in clean water in the battery jar for 48 hours, the water being changed after 24 hours.
4. The cell will then be ready for use in the ordinary way.
5. The acid solution described above can be used three or four times but new acid solution should be added after each porous pot has been treated to make up for waste solution.
6. A record is to be made for each pot as follows: (a) Date pot is returned to service. (b) Nature of circuit, telegraph, or block, etc. (c) Date pot is taken out of service.

Test data are given which show that porous pots renovated in the above manner give very satisfactory results. The action of the acid solution is no doubt to neutralize the alkaline salts and give the contents of the porous pots an acid reaction. Any free acid is, however, removed by the soaking and washing. Probably the ammonium hydrate collected in the mixture in the porous pot is reconverted into sal ammoniac, but this would also be washed in the washing. The acid also probably dissolves ammonium salts out of the pores of the porous pot, thus giving free passage to solution to the latter, and at the same time reducing the resistance of the cell. If the carbon plate is broken or the terminals have become loose the porous pot cannot be renovated. To overcome the loose terminal difficulty the author advises drilling a hole through the lead and carbon plate and filling the hole with solder.

Spent dry cells are utilized by using their interiors as porous pots for Leclanché cells. The dry cells are used on important circuits until they give on testing one to two amps. momentarily; they are applied then to unimportant circuits until they are entirely spent. The remaining material is then utilized as follows: the zinc outer case is removed and the jelly electrolyte is washed away, leaving the sac interior, which contains the usual carbon rod, surrounded by a mixture of carbon and pyrolusite. A little of the pitch recovered from the old dry cell is heated and placed on top of the sac and around the carbon rod; or the top of the sac and carbon rod, when dry, are varnished with an insulating varnish or paraffin wax to prevent the salts from creeping. The sac is then ready for use as a porous pot with the ordinary zinc rod and sal ammoniac solution in a glass jar, thus forming a Leclanché cell. If a spent dry interior, after being washed, does not give satisfactory results on testing it is submitted to the hydrochloric acid process as in the case of porous pots but for a shorter period.

It was suggested during the discussion that porous pots returned from service with a high internal resistance may be renovated simply by boring holes through the porous pot. It was also suggested that there is no need to remove the sac from a spent dry cell in order to obtain further service from it. It is sufficient to strip the outer cardboard, puncture the 'zinc in a number of places and put the whole in a vessel containing sal ammoniac solution. The only objection to this is the size of the containing vessels which have to be used.—*Electricity* (London), June 25, 1920, pp. 391-92.

NEW METHOD OF TRANSFORMATION FROM TWO-PHASE TO THREE-PHASE AND VICE-VERSA

THE originator of the system described is J. Kübler, particulars being given in Swiss patent No. 82681. It is claimed that it is more advantageous than the time-honored Scott method as it requires the use only of a suitably wound three-phase transformer and thus is cheaper in initial cost than the former which requires two single-phase transformers. The new method is also simpler than the arrangements devised by Stern and the Gessellschaft für Elektrische Industrie. It is also shown that the transition from two-phase 40-cycle supply to three-phase 50-cycle supply, which is commonly being carried out in Switzerland and Austria in order to connect existing systems to the long-distance distributing systems, can be effected by very simple reconnections of the transformer windings that can be carried out on the site. The voltages on load are better balanced than in the Scott system.

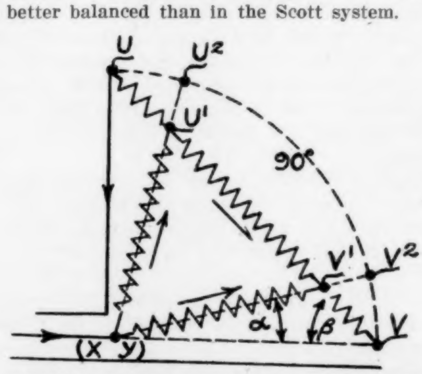


DIAGRAM OF TRANSFORMER CONNECTIONS

The diagram shows the arrangement of the secondary windings of the transformer, the primary being a normal three-phase winding in star or mesh connection.

One limb of the transformer carries the winding U'—(X Y), the second—the winding V'—(X Y), and the third—the windings U — U', U' — V', and V^1 — V. If W_2 is the number of

turns on each of the star-connected portions of the secondary of the secondary winding and W_2' the number of turns on each of the portions $U - U'$ and $V' - V^2$, then $W_2'/W_2 = \sin \alpha / \sin \beta = \sin 15°/\sin 45°$; hence $W_2' = (\sqrt{3} - 1)\frac{W_2}{2}$. If D_2 is the current per phase on the two-phase side, the sections $U - U'$ and $V - V'$ carry the current I_2, then the sections $(X\ Y) - U'$ and $(X\ Y) - V'$ carry currents $I_2\sqrt{2}\sqrt{3}$ displaced 60° from each other in phase, and the section $U' - V'$ carries the current $\frac{I_2\ (\sqrt{3} = 1)}{\sqrt{6}}$ or approximately $0.3I_2$. The latter section acts as an equalizing winding that renders the symmetrical transformation from three- to two-phase possible.

A calculation of the total copper losses shows that if A kva are to be transformed from two- to three-phase the three-phase transformer required is one of which the normal rating is 1.07 A. The article discusses the 40 to 50 cycle, two- to three-phase change referred to above and shows how it may be carried out; it appears that after the change the output of the transformer may be increased 30 per cent for equal heating.

The connection shown in the figure is given for a two-phase system with common third wire, but connection for a two-phase system with four wires may also be obtained by a modification of the arrangement.—K. Sachs, *Schweiz. Elektrotechnischer Verein, Bulletin*, February, 1920, pp. 23-32. Condensed in *Elektrotechnik und Maschinenbau*, March 7, 1920. Abstract in *Technical Review*, June 8, 1920.

ROTATING ARC LAMPS OF GARBARINI TYPE

THE author describes and illustrates a new arc lamp in which the positive electrode is a cored carbon rod of the conventional type; it is a good electric conductor, is of low thermal conductivity and furnishes the luminous crater. The negative electrode is a metallic ring cooled by circulation of water or oil surrounding and presenting its inner edge toward the crater. When the arc is struck it is comparatively stable at the end of the carbon electrode while it is oscillating at the inner edge of the metallic ring, which modifies greatly the size and direction of the crater. This instability of the arc is greatly increased by having a solenoid arranged in such a manner as to create a magnetic field having the positive electrode for its axis. The arc proper is subjected then to this magnetic field and it is caused to rotate at 500 to 300 r.p.m. This rotation is so rapid that it is impossible for the eye to note it, and the arc appears as a highly incandescent point surrounded by a bluish halo.

The advantages of this new lamp are summarized as follows: The close approximation to the theoretical point source of light is obtained; the luminous center is fixed with regard to the lamp itself; the source of light is fully utilized, an arc is provided of constant length, constant ohmic resistance and intensity; only the positive electrode is consumed; the regulation is independent of the voltage and current of the arc and is a function only of the location of the crater relative to the fixed parts of the lamp; it is accomplished by the dilatation of a metal strip.—Garbarini. *Bulletin Officiel de la Direction des Recherches et des Invention*, January, 1920, No. 3, pp. 143-48. Condensed in *Revue Générale de l'Electricité*, April 10, 1920, p. 508.

A COÖPERATIVE COURSE IN ELECTRICAL ENGINEERING

THE educational scheme known as the Coöperative Plan is not new in itself. That there are distinct advantages in acquiring theory and practice at the same time has long been recognized, and several technical schools, notably those abroad have been operating on this plan for several years. The College of Science and Arts in Glasgow, the Faraday House in London and the University of Copenhagen in Denmark are well known examples. In this country coöperative work was inaugurated by Dr. Herman Schneider at the University of Cincinnati. Courses similar in detail have been operated by the University of Pittsburgh and by Marquette University at Milwaukee. However, the coöperative course of the Massachusetts Institute of Technology differs in several important respects from the coöperative schemes of other institutions, to which differences attention is called below:

1. At Massachusetts the coöperative course does not take the place of the regular course in electrical engineering, but is rather an addition thereto, and its main purpose is to train only one type of electrical engineer—the engineer who is to be intimately connected with the design and manufacture of electrical machinery and accessories. This type of engineer superintends the design and manufacture of most of the apparatus used by the administrative and consulting engineer. His qualifications call for an intimate knowledge of the best manufacturing processes and a thorough training in modern research methods. It is these men who in the last analysis must direct the operation of the nation's industries and therefore, no doubt, stand most in need of such a coöperative course.

2. The course covers a period of five years, the first two years being identical with the regular course in electrical engineering. The coöperative features thus occupy the last three years. The first week in July, the entire class who have just completed their sophomore year are sent to the General Electric Company's work at Lynn. Here they remain for thirteen weeks. At the opening of the fall term at the institute one-half of the students return to Cambridge and pursue for one term what is practically the regular course in electrical engineering. At the end of this term they have a vacation of two weeks and then go back to the works of the General Electric Company for further experience. The other group now returns to the Institute for further theoretical instruction. The last period of the fifth year is spent by both groups at the institute so that the two groups graduate together at the regular commencement time. At the completion of the five-year course the students receive the Master of Science degree and the Bachelor of Science degree.

The periods of thirteen weeks at the shop and eleven weeks at the institute are based on the consideration that the courses at Technology take ten weeks, and that all longer coures take some multiple of ten weeks. The student is thus able to pursue his studies at the institute in units of standard length. On the other hand, the thirteen weeks' factory period seems to be the proper amount of time for the student to spend in certain advanced departments so that he could thoroughly and without interruptions acquaint himself with the men, methods, materials and spirit of those departments. This, however, does not prevent him from dividing his time among two or three departments in case he is able to master the details in a shorter time.

3. The real vital difference between this course and other coöperative courses conducted in this country is the spirit of earnest and whole-hearted coöperation on the part of the General Electric Company. In pursuing this work the officials of the company believe that by this method they can procure the future engineers who will so badly be needed by the company and by other industrial concerns in the future. Consequently, there is not the slightest effort on the part of the company to use these students for the purpose of getting out immediate production. The length of time spent in each department is regulated not by the needs of that department but by the value of the experience to the student. As soon as it is deemed that he has all the knowledge of the details of the department he is immediately changed to another department. The change is made upon consultation between the foreman of the shop and the officer of the company and the professor of the institute who are associated in conducting the course. While at the works the students are given a fixed payment per week as employes of the company; this payment is the same for all the departments of the works.

Perhaps the spirit of full coöperation on the part of the company is most clearly manifested in the attitude of everyone connected with it. The busy superintendents find time to prepare and give talks on the details of the work of which they are in charge; others illustrate these talks with lantern slides; some have prepared exhibits of the work in the shops, showing the material in the different stages of manufacture. The policies of the company are also reflected in the very courteous treatment of the students by the subordinates and workmen. Whenever the student assumes the proper attitude he has also a large field here for study and experience in human engineering.

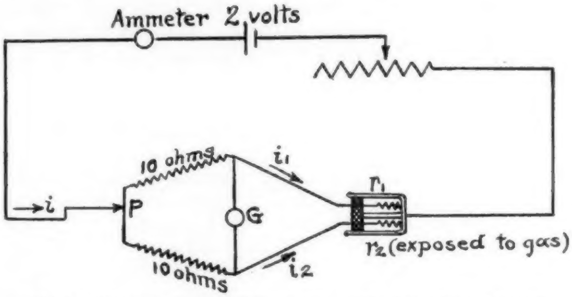
4. In arranging the general details of the course it was endeavored to fit it into a system of education which the founders believe is basic. This system combines the rudiments of Spencer's theory of education with the central idea of Josiah Royce's. It is an endeavor to develop all the desirable sides of a student's mind, character, and body, and at the same time inculcate in him the spirit of loyalty to his life's work. Under this system the continuity of the theoretical studies and humanistic subject is quite important and this may be mentioned as another difference from the usual coöperative courses. All through the course, both while at the Institute and during his sojourn at Lynn the coöperative student is pursuing the study of electrical engineering theory. At the same time he is taking courses in the study of English. Provisions are also made for further liberalizing the engineering students' education by means of collateral reading. The students while at Lynn live together at the Thompson Club which is provided with private rooms for individual study, an assembly room for class work, a library, a billiard room, shower bath, etc. This club house forms a center of activities, and here all class exercises are held. Advantage was taken of this arrangement to equip the library with a wide assortment of technical books from the Institute library, and arrangements were made with the Lynn Public Library whereby several shelves are kept filled with books on all sorts of subjects and in many fields of literature. The Institute thoroughly believes in the desirability of creating the habit of general reading on the part of the engineer. This is in line with the conviction that if men with engineering training can be induced to bring this training to bear on public questions and civic affairs a great dynamic for good will be put into public life.

Another point of difference is the spirit of loyalty which is being inculcated in the members of this course, a loyalty to one another, to the institute and to the coöperating company. Also the keeping of the students in the plant of the same coöperating company throughout the three years, and the unusual amount of theoretical work in the course.—W. H. Timbie. *Engineering Education*—Bulletin of the Society for the Promotion of Engineering Education, June, 1920, pp. 459-76.

THEORY OF THE KATHAROMETER

DURING the war a need was felt for an instrument capable of giving automatic indication of the presence of hydrogen in small quantities in air. At the request of the Board of Inventions and Research of the Admiralty, Mr. G. A. Shakespear, with the assistance of H. A. Daynes, devised such an instrument. As it was primarily intended to measure the purity of air, the name "Katharometer" was given to it. Its construction is based on the well-known surface-action of platinum wire. The wire was used as two arms of a Wheatstone bridge, one of these arms being protected from the gas by a thin glass tube, the other being exposed. When a sufficiently great current of electricity passed through the bridge, the exposed arm rapidly increased in temperature owing to surface combustion. The temperature, however, was liable to rise dangerously high if the hydrogen were present in suitable quantity, and, as safety from explosion was indispensable, this method was abandoned. The same apparatus was then applied with a much lower current, and with the wires consequently at a much lower temperature, to make use of the increase in thermal conductivity of the gas due to the admixture of hydrogen. This arrangement was found to be unexpectedly sensitive, and the method was adopted for the desired purpose.

In the final form, the katharometer consisted of two small helices of thin platinum wire, enclosed each in one of two cells in a copper block. Each helix was mounted in a small frame consisting of a loop of copper wire soldered to a ring of copper. This ring was fitted with an insulating plug through which the lead wire, also of copper, was introduced. One extremity of the helix was soldered to the lead and the other to the distal end of the loop. The outer part of the lead passed through a plug of rubber fitting into the cell, and over this rubber an ebonite plug was pressed down by a screw collar or nipple. Thus, the rubber filled tightly the upper part of the cell, and access of air or gas could only take place by diffusion in the rubber. Both cells were similarly fitted, but whereas one was hermetically sealed the other communicated with the outer atmosphere through three small holes. The resistance of each helix was about ten ohms; it was wound from about 8 cm. of pure platinum wire 0.001 inch thick, the diameter of the spiral being about 1 mm. The main working current in the bridge was usually 0.100 ampere; this was sufficient for most pur-



ELECTRICAL CONNECTIONS OF THE KATHAROMETER

poses and gave the wires a temperature about 15°C. above that of the block. The remaining arms of the bridge were of manganin wire. The diagram shows the electric arrangement. As seen from the diagram the other arms of manganin are joined by a graduated bridge wire, and the point of contact (P) is always varied so that the galvanometer (G) gives zero reading. The current is always adjusted to a definite value.

The instrument proved valuable for war purposes in various ways, e.g., in testing the purity of hydrogen in balloons, testing the permeability of balloon and airship fabrics to hydrogen, testing permeability of sheets of metal, etc. The katharometer has already shown itself a valuable instrument for research and is evidently capable of wide application. Mr. Daynes develops a complete theory of this instrument and discusses at length the heat losses in the katharometer cell, and corrections and methods of practical application. In a following paper entitled: "Process of diffusion through a rubber membrane" the same author shows how this instrument is used, as part of the Shakespear permeater tester, in the investigation of the question of leakage of hydrogen through balloon and airship fabrics.—Proceedings of the Royal Society. Series A, Vol. 97, No. 685. June 1, 1920, pp. 273-307.

PROGRESS IN ELECTRIC ENGINEERING DURING THE WAR

THE author purports to review the progress made in electric engineering in the various countries during the war; however he pays particular attention to the developments that took place in Germany; he cites numerous important references mostly in the Elektrotechnische Zeitschrift and this enhances the value of his paper as a bibliographic contribution.

The size of steam turbines and alternating current turbo-

generators has been greatly increased. The A.E.G. and S.S.W. have built turbines of 60,000 kva. at 50 cycles and 1,000 r.p.m. Considerable progress has been also made in driving turbines through gearing; especially is it true of England and the United States where the gearing is used either for driving generators or for ship propulsion.

Outside of Germany air filters for electric machines have been used previous to the war; these were of the air washer type, such as manufactured by the Sturtevant Company and others. In Germany different types of air filters in which fabrics are not used have been developed and this change will probably outlive the war conditions.

Great progress has been made in electric driving of ships, and in particular of submarines; in the case of the latter type of vessels a special connection has been devised by Trettin and Hülss in which direct-current motors are used without a starting resistance. It is becoming more common to transmit from the turbines to the propellers of ships by three-phase current. Germany used in war electrically-controlled torpedo boats. Not much appeared in the press on the single armature converter. The work of Linke has cleared up the commutation difficulties connected with this converter by explaining the harmful effect exerted by the fifth and seventh harmonics in the voltage curve.

The A.E.G. have developed a standard unit for supplying 10,000 volts direct current by using 4 commutators in series, each of 2,500 volts. They also constructed large transformers of 22,000 kva. capacity, and very recently a transformer of 50,000 kw. has been built. In electric traction most of the new installations in Europe are being made for 16 cycles with a few but powerful motors on each locomotive. In America the split-phase installations have been described. Considerable attention is being given to direct-current, voltages up to 5,000, having been experimented with. Various types of ventilated railway motors have appeared. Brown-Boveri, Hartman and Brown and others have developed mercury vapor rectifiers of capacities up to several hundred kilowatts. These are being experimented with also on the electric locomotive, although it seems that with the adoption of a high voltage railway motor these rectifiers will find their place in the sub-station rather than on the locomotive.

Rüdenberg contributed important papers on the theory of standardization; he suggested that standards be adopted having for their ratios the roots of ten. Important progress has been also made in electric welding, particularly as it has been applied in shipbuilding.

On the whole, nothing of great importance has been invented in the field of dynamo-electric machinery during the last five years.—E. Rosenberg. *Elektrotechnische Zeitschrift*, February 26, 1920, Vol. 41, pp. 165-66.

Survey of Progress in Mechanical Engineering

Prepared Under the Auspices of the American Society of Mechanical Engineers

LIGHT STEEL CASTINGS

By R. J. DUNDERDALE

THIS type of casting was not extensively used in England prior to the war, one of the reasons for it being that the small converters which were then a source of steel for this type of work did not produce an entirely suitable metal. The situation, however, has become entirely different with the introduction of the electric furnace.

The types of furnace chiefly in use in England for light steel castings are the Schneider, Heroult and Electro-Metals in sizes varying from ½ ton to 15 tons at a charge. The suitable size for general work in castings ranging from 14 lb. to 140 lb. weight is the 2-ton furnace, but even then it is desirable to have the furnace graduated in size and used near the type of casting which they would be chiefly employed on.

The sand required for this type of molding differs materially from the usual iron foundry sand. Its physical condition should be hard, sharp and not easily friable. Chemically, it should contain 97 to 98 per cent of silica and as little matter of other kinds as possible. The sand itself should not pass through an 80-mesh screen as its texture will be rendered decidedly finer than this by the clay used for bonding. The best clays for this purpose contain about 30 per cent of alumina and as little organic matter as possible (a certain amount of iron is said to be an advantage). The moisture of the final mixture which must be good can be as much below 4 per cent as will allow the sand to hold together well.

Baking the mold and painting it with tar from time to time used to be common practice prior to the war. As a matter of fact, however, for a vast majority of light steel castings now made a green mold is entirely satisfactory. A baked mold is still used, however, for very thin work and cored pressure work, providing the mold is made suitably weak and well vented.

A good deal of trouble is experienced from blowholes when the molding is not right, and in this connection, it is stated that the practice of piling is probably not so successful as might be expected owing to the steam generated in the lower molds getting into the upper molds before the steel does and preventing the exit of gases. This same trouble is apt to occur when two patterns are cast separately in the same box.

Core making in a light steel casting foundry has now become a very important part of molding. As regards the sand used in core making, one similar to but rather finer than the facing sand for the molds is desirable.

The causes of the more important failures in light steel castings are discussed in some detail. The three main causes mentioned are short-run castings, slag, and blown and spongy castings.

For repetition work on light steel castings the jolt-ramming type of machine appears to be particularly suitable. In a steel casting it is essential that the face should be hard and the backing moderately weak, in order that the high temperature of the metal and its weight should not break up the face in the first place and the slower cooling portions shall not be drawn apart by a mold which is uniformly too tightly rammed. The jolt-ramming machine provides this.

As regards fettling, the usual tumbling boxes have not been found sufficient for the hard burning on which takes place in the case of a steel casting, especially in the angles and curves of intricate specimens. Sand blasting has to be resorted to, preferably with steel shot and nozzles.

The development of the light steel casting industry in England faces the competition of Switzerland, Belgium and Germany, where the same industry appears to be quite firmly established. At present the rate of exchange is in favor of England and it is stated that the future of the industry should be good for some years to come in any event, but there are several weak spots which are apt to be uncovered when competition begins to arise. As a way to help establish this young industry while it is now in a healthy infancy, it is recommended that the light steel castings users combine with the present manu-

facturers and arrange to parcel out the work to the manufacturers in such a way that one firm is only engaged on two or three standard types of job, this covering the field of repetition work. With regard to the jobbing work, any small quantities of this type should be reserved entirely for two or three foundries suitably equipped with proper range of furnaces.—*Engineering*, Vol. 110, No. 2849, August 6, 1920, pp. 167-168.

STEAM AND FRICTION STAMPS FOR HOT STAMPING

By W. H. Snow

The author compares American and British practice in the matter of production of stampings and comes to the conclusion that American methods are far superior to the British. He explained it by the fact that the American stamper has had the advantage of a demand for quantities altogether beyond the orders usually met with in England and hence has been able to specialize to a high degree.

The author points out several constructional differences between American and British types.

American stamps, both broad drop and steam, are self-contained, *i. e.*, are built entirely on their anvil blocks. The British drop stamp follows ordinary steam hammer construction in having the anvil block and the supports carrying the lifting gear independent of one another. The requisite alignment of the anvil block and tup is secured by resting guides in the block, the upper ends of the guides being supported laterally by the framework carrying the lifting gear, and being free to move vertically. In this way fewer parts of the stamp are affected by the shock of the blow, and a rigid foundation can be used, making for greater efficiency of blow. It is common to place the block directly on the concrete bed, though it is better to interpose a layer of timber of moderate thickness.

American stamps are generally bedded on timber to a depth of several feet—a rather costly arrangement—an elastic foundation being necessary to soften the shock of the blows on the stamp framework, etc., which carried on and bolted direct to the block would otherwise suffer unduly. In the case of steam stamps, the piston rod is a vulnerable part, and excessive rigidity in the foundation would result in a very short life. Experience has shown that nothing but the best materials are admissible in this type of stamp, if frequent and costly stoppages are to be avoided. In the best American practice, nickel chrome steel, specially treated, is used for piston rods and heavy bolts, the tup is of specially selected steel, and the frames steel castings.

In British stamps the guides for the tup are generally straight bars of steel or iron or steel castings of simple form carrying single or multiple "vees" engaged with the tup. The bars rest in holes in the anvil block, and are suitably held in the upper framework, as already mentioned. The lower ends of the bars are generally wedge-shaped, the holes in the block being formed to correspond so that the bars can accommodate themselves to some extent in the event of the block settling unequally and getting tilted. This is a bad arrangement, because the bars jump under the blows and then getting loose momentarily can twist, with the result that the tup is thrown out of alignment with the block.

In American stamps, the standards, fitted with adjustable slides for guiding the tup, are made as supports of ample proportions for carrying the cylinder or the headgear, and are spread out at the base and accurately fitted to the block, which is a much better arrangement.

The universal practice as regards the upper dies is to dovetail and key it into the tup. In American stamps the same plan is adopted for the lower die. A strong steel die holder of ample area is dovetailed into the block and the die is held by dovetailing in the holder. There are no ready means of altering the position of the dies in relation to one another, and reliance is placed on accurate sinking of the impressions to secure the correct registering.

The general practice among British stampers is to have poppets fitted to the anvil block and to hold the die between screws—usually four in number—working in the poppets and pointing radially. (In France and Belgium six poppets with screws on rectangular axes are favored.)

There is also a material difference in the stamping processes used in the two countries. In America practice preparing for preliminary forming as well as the stamping of the article is done as far as possible under the same stamp. The original British method is to employ a dummying or preparing stamp alongside the main stamp and to rough out the article under it between suitable tools arranged with narrow and wide bases by the ordinary forging process. A variant on this plan is to use fast running steam or power hammers for preparing quite independently of the stamping, the pieces being forged in numbers and then taken away to be reheated for stamping. This is a considerable improvement on the older method, as the saving in time by using high-speed hammers more than compensates for the cost of reheating and a much larger output per stamp is obtained.

An interesting feature of the British methods is disclosed by the author when he calls attention to the fact that the use of forging machines for upsetting is unknown in England.

The conclusion to which the author comes is that the British practice needs overhauling. He calls attention, however, to the fact that if American stamps were installed, but no change of methods of working adopted, the full advantage of their construction would not be realized. On the other hand, it would not be feasible to work on American lines with British stamps as their construction is much too weak for this.—*The Engineer*, Vol. 130, No. 3373, August 20, 1920, pp. 173-174.

THE LAWS OF HIGH-SPEED PUNCHING

By Capt. T. J. Tresidder

A paper has been issued by the War Office, Ordnance Committee Press, presenting a novel theory of punching which the author calls the Seriatim Theory of High-Speed Punching.

The theory is of importance also to artillerists as it permits of determining the remaining velocity of a projectile perforating a plate at a given striking velocity.

The method of procedure according to this theory is to separate the energy expended in perforating into its three components, namely, that expended on punching, that expended on overcoming friction, and that expended on giving velocity to the expelled plug, the laws governing the punching of a plate by a projectile being claimed to be exactly the same as those known to obtain in the case of plates punched in a punching machine.

The basic argument brought forward is to the effect that mean endlong pressure on the shell due to resistance to punching decreases as the velocity of the shell increases from the bare perforating velocity upwards.

There is an important distinction between the blow the projectile can give and that which it does give. Up to bare perforating velocity it gives its all. Beyond perforation point the blow given is only the maximum the plate can return, and the rest of its possible blow the shell carries on with it.

When a moving body, say, a shell—collides with a stationary one—say, a plate—the action and reaction between them, which are equal to each other, obviously cannot exceed the maximum of which the more feeble is capable. If the blow is arrested, the shot is the more feeble and the mean pressure will depend on its energy. If it is not arrested the plate is the more feeble and the mean pressure will depend on its resistance. If the latter decreases—according to the theory about to be propounded—as speed of attack increases and makes the time available less sufficient for calling into action all the resources of the plate, pressure must decrease with it. Therefore, a shell which encounters a plate with only just enough velocity to perforate it will be more stressed by, and will undergo more endlong pressure from the plate's resistance than if its velocity were twice as great.

Consider the force required to punch, as in a punching machine, four plates, each ¼ in. thick, arranged with three thinner hard plates, which have been already perforated, between them. The thin hard plates—that is, the second, fourth and sixth of the pile—will then act as holders-up for the first, third and fifth, the seventh being held up by the die of the machine as usual. Clearly the pressure that must now be applied to the punch to perforate the four 1.4 in. plates—1 in. altogether—is theoretically only the same as would be needed for one ¼ in. plate. That is to say, if a punch can deal with a plate by punching one-fourth of its thickness at a time, it need only have behind it one-fourth the pressure otherwise necessary. Similarly, if a plate is made up of a thousand or ten thousand laminae which can be separately punched seriatim, the theoretical force of pressure between punch and plate need only be one-thousandth or one ten-thousandth of that required for the solid plate. The distance separating the laminae need only be sufficient to allow each to fail to shear before the next is seriously engaged, and as this distance will certainly be less as the speed of punching is greater—for the higher the speed the more thoroughly is each lamina held up by its own inertia—it is not inconceivable that as V increases toward the infinite, there will be, in the case of a solid plate, a nearer and nearer approach to a sort of seriatim punching of hypothetical laminae, whose number approaches infinity and whose thickness and distance apart approach zero.

This is followed by an interesting discussion of the classical case of a candle fired as a projectile through a wooden board.

The author's theory was checked by means of tests where measurement was made of the loss of energy suffered by certain projectiles in perforating certain plates at velocities far above those just necessary to carry a shell through. The bare perforating velocities were known. Knowing the energy lost by the projectile when it just perforated and calling it A, and also knowing the energy lost by the same projectile in perforating the same plate at a higher velocity and calling it B, it was only necessary to compare A and B to test the truth of the main assertion of the Seriatim Theory, namely, that mean pressure due to resistance to punching is less as perforating velocity is greater, which proved to be true in every case.

The approximate net energy absorbed in overcoming the plate's resistance to punching at the high velocity—based on the observed remaining velocity—was compared with that at the low velocity. Their relation to each other was found every time to be, within reasonable limits of observational accuracy, inversely the same as the relation of the corresponding striking velocities.

This amounts to experimental proof of the statement that the net energy absorbed in the punching of a given plate by a given projectile, and also the mean pressure F on the projectile due to the plate's resistance to punching, varies inversely as the striking velocity.

It will be seen that, according to the Seriatim Theory, as V proceeds from perforation value to infinity, "pressure exerted," "work done," and "time taken" in overcoming the plate's resistance to punching, all diminish toward zero; but "power exerted," which is work divided by time, remains the same at all velocities, if t is fixed, since, however to zero "work done" and "time taken" may be brought, their relation to each other remains unchanged, both varying inversely as the first power of the velocity.

Bearing in mind, then, that in the perforation of one body by another, energy is expended in three distinct ways, viz., punching, friction overcoming and plug propelling; and that of these we are at the moment dealing with only one, namely, punching; the following new dynamical law seems to result from the arguments of this section:

When any given body, in virtue of kinetic energy, passes completely through another given body without undergoing any change whatever of its own form or dimensions, the power it exerts in effecting the necessary rupture of the material of the perforated body is constant for all velocities.

The report covers many more features of apparently great importance which cannot be abstracted, partly because of lack of space and partly because of insufficiently explicit data in the abstract from which this one is taken.—*The Engineer*, Vol. 130, No. 3371, August 6, 1920, pp. 126-127.

THE BOWDEN PETROMETER

Description of a device acting electrically which registers the fuel consumption on a motor vehicle or airplane from moment to moment under all conditions.

As shown in the drawing the petrometer consists essentially of a vessel divided more or less centrally by a diaphragm in which three passages are formed. One of these passages on the left is connected to the main supply pipe from the tank and can be closed by a needle valve; the second passage connecting the upper and lower chambers is opened and closed by another and larger valve. The third passage through the

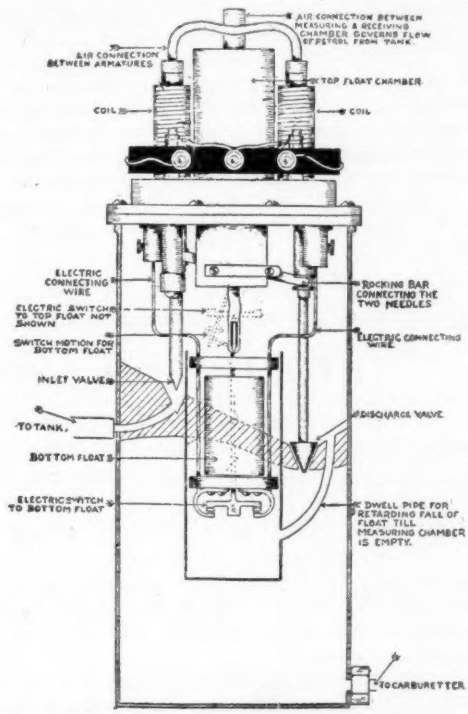


FIG. 1. THE BOWDEN PETROMETER FOR MEASURING FUEL CONSUMPTION OF A MOTOR VEHICLE ENGINE

diaphragm connected by a pipe to a central barrel is set midway through the diaphragm and is equipped with two disks with a float chamber between them.

Beneath the lower disk are two curved contact pieces, wired through this disk and the upper one—and rigidly, for constructional support—up to the terminals of the coils, which are mounted on a platform above, and outside the fluid-containing vessel, along with an upper float chamber, the armatures—not shown—that carry the needle valves, and the positive terminals from the source of electricity. Each float is mounted in a central spindle that carries a tungsten-tipped contact bar which makes or breaks the electrical circuit for the upper or lower "loop," so to say, thus established, as it makes or leaves contact with the stationary contact pieces, making—in the case of the lower float chamber—only while it is empty, but breaking the moment the float lifts, when the lower or measuring chamber is full. The upper contact bar, on the contrary, makes contact from the moment the petrol is free to enter the upper or receiving chamber, and lift the upper float, and does not break contact until the upper float chamber is empty. The two needle valves are interconnected

by a centrally pivoted rocking bar, which carries a free arm extending downward at a right angle to it, to engage a loop from the spindle of the lower float. The function of this arm and loop would simply steady the fall of the lower float.

All that is apparent from the diagram is that during the "make" of the lower float contact bar, the left-hand coil is energized to lift the inlet needle valve beneath it, which remains lifted until the upper float chamber is sufficiently full from the reception of the petrol for the upper float to lift its contact bar into "make" contact; which action is simultaneous with the "break" of the lower contact-bar from the lift of the float in the lower chamber by the entry of a certain amount of petrol through the free connecting or dwell-pipe meanwhile. Then at the break of the latter, simultaneously with the make of the former, the left-hand coil is de-energized to drop its needle-valve, while the right-hand coil is energized to lift the discharge valve into the measuring chamber, which, is in free connection with the carburetor.

The discharge valve is mechanically connected with the dial so that the moment it closes it registers the amount it has admitted into the lower or measuring chamber. The dial has two sets of hands—one, non-adjustable, registering the gross fuel consumption, and the other with a trip hand adjustable for the run consumption. In the lower float chamber there is also installed a damping disk, which, acting like a paddle in the constant amount of fluid renders the apparatus proof against jerking or oscillation, which is an important feature. —*Auto-Motor Journal*, Vol. 25, No. 31/1021, pp. 799-800.

AIR-COOLED SLEEVE-VALVE ENGINE

A RADIAL 3-cylinder motor-car air-cooled engine fitted with the Burt single-sleeve valve is described in a recent issue of the *Autocar*:

The engine has a bore and stroke of 60 by 90 mm. Its most interesting feature is the sleeve valve. The sleeve is given a movement which is a compound of up and down and rotational movements so that a point marked on the sleeve would in a complete circle trace an ellipse.

The sleeve is operated by means of a small crankpin carrying a short horizontal connecting rod, the small end of which is attached to lugs at the bottom of the sleeve by means of a pin having a vertical axis, that is an axis at right angles to the axis of the crankpin.

The place of the usual camshaft is taken by a small crankshaft driven at half engine speed with separate crankpins for each cylinder.

There is a separate crank for each cylinder driven by means of skew gearing, the crown wheel of which is mounted at the side of the main crankshaft remote from the fan.

One of the features of the valve system is that inlet and exhaust ports are placed alternately round the cylinder, and the ports in the sleeve act therefore alternately for admission and exhaust, which helps to cool the sleeve. The cold incoming mixture circulates round an annular space at the top of the cylinder, cooling the latter and also the cylinder head.—*The Autocar*, Vol. 45, No. 1296, Aug. 21, 1920, pp. 317-318.

Progress in Mining and Metallurgy

Abstracts of Important Recent Papers

Prepared Under the Auspices of the American Institute of Mining and Metallurgical Engineers

HYDROMETALLURGY OF COPPER SULFIDES

BY WILLIAM E. GREENAWALT

IN 1912, when my book, "The Hydrometallurgy of Copper" was published, there was not a single electrolytic copper extraction plant in successful operation. The book concludes with the following remarks:

"The prevailing idea, especially in metallurgical literature, seems to be that the hydrometallurgical processes for the extraction of copper are applicable only to low-grade ores. But why limit them to low-grade ores? There is no reason why wet methods should have any limitations, either as to the grade of the ore or its mineralogical composition, provided the process is chemically adapted. This adaptation will, in its ultimate analysis, resolve itself down to the consumption of chemicals, the same as in chlorination, cyanidation, or smelting.

"Copper is one of the most readily soluble of all the metals, and one of the most readily precipitated either chemically or electrolytically. Theoretically, the solvent processes, especially the electrolytic processes, offer all that could be desired, on ores chemically adapted; close extraction, cheap deposition, copper in its metallic form, saving of the precious metals, the installation of plants at the mines which may be operated in any unit and without admixture of other ores or fluxes. With these theoretical advantages it is reasonable to suppose that the chemical methods will ultimately be in as general use for the extraction of copper as the cyanide and chlorination processes now are for the extraction of gold and silver."

Since the book was published many large copper leaching plants have come into successful operation. Two of the largest copper mines in the world are now using electrolytic processes exclusively, operating on low-grade oxidized ores. There does not appear to be a single plant in operation treating concentrates or high-grade sulfide ores. There is one large plant treating sulfide tailings which require roasting, but in this plant the copper is chemically precipitated.

Up to the present time only two methods of precipitation have looked promising in connection with purely chemical processes—iron precipitation and hydrogen sulfide precipitation. In iron precipitation, both the acid and the iron are irrecoverably lost, and the expense is ordinarily prohibitive. With hydrogen sulfide precipitation, the acid combined with the copper is regenerated.

The outlook for the purely chemical processes in the general hydrometallurgical treatment of copper ores is not hopeful, because they are usually too expensive to operate, and the end product is in a very unprofitable and undesirable form, unless a smelter and refinery are operated in connection with the hydrometallurgical plant.

The application of electrolysis to leach copper solutions appears to be very simple; it is, in fact, quite difficult. The entire problem of copper electrolysis from leach solutions resolves itself down to the problem of the ferric and ferrous salts in the electrolyte.

PRECIPITATION

In the extraction of copper from suitable ores by a wet process, the vital step usually lies in the method of precipitation. Chemical precipitation does not present a hopeful outlook, and it appears to be quite impossible if a high-grade ore or concentrate is to be treated; for, in addition to the expense of chemicals for precipitation, the resulting precipitate represents simply another stage of concentration, and not a product that will command the highest market price, and which is salable direct to the consumer.

Although electrolytic precipitation presents some difficulties, they are not insurmountable, and it is the key to the situation. The problem of the electrolysis of leach copper solutions can be focused on the action of the iron in the electrolyte. Both at Chuquicamata and at Ajo, the deleterious effects of the iron in the electrolyte are kept within workable limits by a process of close elimination above a certain low percentage of iron.

The power required for the electrolytic deposition of the copper and regeneration of the solvent in electrolytic plants is one of the most formidable items of expense, both of installation and operation.

The hope of the independent copper miner lies in the hydrometallurgical processes, and above all, in the electrolytic method of copper deposition and acid regeneration. This applies with particular emphasis to mining districts where fuel is abundant and where power can be cheaply developed, and especially to districts remote from lines of transportation. It seems almost unbelievable that a field so promising as electrolytic extraction processes should have been so long neglected.

The small and independent miner who can rely on a steady supply of ore may no doubt, in a few years, be shipping electrolytic copper instead of ore and concentrates.

RECAPITULATION

1. Hydrometallurgy offers an effective solution to the problem of high shipping and refining costs of copper ores and concentrates.

2. The hydrometallurgical treatment of copper sulfides should follow along the lines of roasting, leaching, and electrolysis of the leach solutions to obtain the electrolytic metal and regenerate the solvent.

3. Electrolytic extraction plants may be installed in any unit and successfully operated without the admixture of other ores or fluxes.

4. Electrolytic processes are applicable to sulfides as well as to oxides; to concentrates as well as to the ore direct.

5. Electrolytic extraction plants are expensive to install but are highly efficient.

6. An electrolytic process on suitable ores takes the place of smelting the ore to copper matte; of converting the matte to blister copper; and of the ordinary refining process to convert the blister copper into the electrolytic metal.

7. The process is applicable to copper matte, if smelting is advisable as a preliminary treatment for ores which are not otherwise amenable to direct treatment with an acid solvent.

8. Cheap power is one of the essentials of an electrolytic process, and cheap water power can frequently be developed in the vicinity of copper mines, especially in the Rocky Mountain regions.

9. On the basis of 1 cent per kw-hr. for power, the power cost for the deposition of 1 lb. of copper and the regeneration of from 2.5 to 3.0 lb. of acid will be 1 cent. The total power cost would be approximately 1.5 cents.

10. It is quite possible that an electrolytic process, treating suitable sulfide ores, can be made self-sustaining in acid. If it cannot, the small deficiency can readily be made up with a small acid plant in connection with the roaster furnace sulfur gas.

11. The vital issue, in the electrolysis of copper leach solutions, will be found in the ferric and ferrous salts. The success of an electrolytic process will depend mostly on the efficiency of the reduction of the ferric salts in the electrolyte, and largely on the extent to which ferrous salts can be used as a depolarizer.

12. Metallurgically, the efficiency of the electrolytic extraction plant is independent of its magnitude. The character of the roast, the extraction of the copper, and the electrolytic deposition of the copper and regeneration of the solvent are about the same for a small plant as for a large one.

13. Electrolytic extraction processes will find their widest application in the treatment of the higher grade ore and concentrates.

14. The end product of all electrolytic processes is the electrolytic metal salable in the open market direct to the consumer.—(Conclusion of paper presented before the Western Meeting of the Canadian Milling Institute.)

DEVELOPMENT OF LIQUID OXYGEN EXPLOSIVE

GEORGE S. RICE, of the Bureau of Mines, is the author of *Technical Paper* 243 entitled "Development of Liquid Oxygen Explosive During the War." After giving a discussion of the German use of this explosive and the experments made at the Bureau of Mines Testing Station at Pittsburgh, Mr. Rice sums up the advantages and disadvantages as follows:

ADVANTAGES

The advantages of using liquid oxygen, as compared with the use of dynamite and black blasting powder, are as follows:

1. Lower cost per unit of material blasted.

2. No danger in transportation of explosives to point of use.

3. Practically no danger of premature ignition.

4. Elimination of the danger of misfires by waiting 30 or 40 minutes after lighting the fuse, when practically all the oxygen will have evaporated.

5. Elimination of the danger of unexploded sticks in mucking, or in the ore or coal going out of the mine.

6. No danger such as is experienced in handling and thawing frozen dynamite.

7. No danger from storage in magazines, as with dynamite and black powder, from lightning, or fire, or miscellaneous ignition.

8. Having a liquid oxygen installation to supply oxygen for special purposes, such as self-contained breathing apparatus and the oxyacetylene torch.

DISADVANTAGES

1. The liquid oxygen because of its rapid evaporation must be used quickly and at a definite time after charging the hole, thus limiting the number of shots that can be fired in any one place to three or four, and making the firing of a group of shots more difficult although this can be done.

2. The practical necessity of having a liquefying plant near the mine to insure a supply.

3. To obtain the liquid oxygen at low cost the plant must be kept running regularly; that is, it is not suitable for intermittent work.

4. On account of igniting firedamp, liquid oxygen explosive cannot be used in gaseous coal mines.

In spite of the disadvantages, the writer is of the opinion that the method has great merit and possibilities for lessening blasting costs in certain classes of mining, as in (1) coal mines which at present use black powder or dynamite, are free from firedamp, and do not produce dust of an especially dangerous character; (2) non-gaseous anthracite mines; (3) iron, salt, and other mineral mines using a chamber method of mining where only a few shots are fired at one time; (4) quarries where a few large shots could be fired at one time. The liquid oxygen could be placed in a special container, and owing to the large quantity of liquid used in a single cartridge there would probably be small evaporative loss.

Correspondence

The editor is not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.

DISINTEGRATING ELEMENTS

To the Editor of the SCIENTIFIC AMERICAN MONTHLY:

In 1869 Mendeleeff arranged a table of the chemical elements in the order of their atomic weights. He was able by dividing these elements into eight groups and leaving certain blanks where very evident intervals of these undiscovered elements occurred to produce a tabulation in which the horizontal lines advanced one after the other in atomic weight and the vertical lines gave groups, all having gradational similarity in their reaction to various agents. He established the periodicity of the properties of the chemical elements in relation to their atomic weight. Further, in the case of the blanks in his table, he was able to predict with marvelous exactitude the properties of the elements, which, when they should be discovered, would fill those blanks. For an early bit of generalization it has been of marked assistance in the advance of chemical science. It points out the undoubted family grouping of elements along certain lines of increasing atomic weight.

Since the days of Mendeleeff many new elements have been discovered and have fallen into their places in his table with, generally, little difficulty. There have been adjustments of the Mendeleeff groupings to the atomic numbers of the elements; but always the object has been the betterment of the family grouping.

A new grouping, unsuspected by Mendeleeff, of the inert gases, of which Helium and Argon are members, has been added vertically to one side of his original table, and his series eleven, Thorium and Uranium, is found to be radioactive, to which Niton and Radium have been added. These new groups contain the evidences of a new and just developing chemistry. The interrelations of Uranium, Thorium, Radium, Niton and Helium are opening a field in which the surface may be as yet but scratched. These are the heaviest of the elements so far discovered coming after the series containing Gold, Mercury, Thallium, Lead and Bismuth. All of them are varyingly rare in occurrence in that part of the earth's crust to which we have access, and yet all of the above, with dozens of others, make up less than one-half of one per cent of this crust.

The earth's crust is but the flotsam of its structure. Its specific gravity approximates 2.6, about that of granite, while that of the whole globe is about 5.6. It is evident that the heavy elements seldom get to the exterior. The heaviest so far discovered are known to have most astonishing characteristics and an interrelation only partly developed. Radium and Thorium are radioactive and are believed to give off electrons and break down into Uranium and eventually Lead. They have revolutionized the theories of conservation of energy and have given basis for vast changes in estimates of the age of our earth and system.

The electronic theory of matter propounds that all matter is made up of minutest particles in whorls of motion. The atom is a system of revolving electrons, a smaller edition of our universe with its sun and planets and wide comparative distances. The atoms of an element are all alike with the same relative motions, but the elements must vary from one another in the number of electrons to the atom and their motions and stability. The more complicated the atom the less the stability. Lack of stability gives radioactivity and change of atomic consistency.

Science then already concedes periodicity of the atom along lines of varying atomic weight and conjectures that atoms vary from one another not in material but in structure. It is but a step further in generalization to believe that there has been a general source of atoms in which the electrons that make them up are in homogeneous mass held in circumstances of pressure and heat, and that in accordance with the variations of release from this mass the families of the elements have found origination—complex possibly beyond measure at first, possibly our proto elements with their varying spectroscopic waves, possibly compounds we have never found. There have been gradual metamorphoses with the releases of vast energies of which at present science has picked up but part of the manifestation, in Radium. It is fair to suppose that there may be further developments of similar and parallel elements and action. Only the borderland has been touched; our knowledge is young. Where matter would be found in this primitive form it is hard to state. We should need to be within the dark room of incalculable heat and pressure to find it. Impact of suns might bring it about. Anything that we could observe would have progressed some distance on the road of breakdown. During such a change one element might go back to its original form and emerge as another element.

How far along the road of disintegration the center of our earth or sun may have progressed is a matter of conjecture. Undoubtedly heavier substances exist at the core than we find on the surfaces: Are there vast masses of the known elements which have not worked to the surface and are there included unknown elements disintegrating by energy emanations? Have we proto elements covered by the debris of their own decay? Shall we find other bases for calculating the age of the universe? Shall we gain new knowledge here, or from spectroscope and nova stars? Radium has upset one corner of chemistry and physics and astrophysics. To what will its outcrop lead?

GEO. N. COLE.

New York.

THE ENGINEERING INDEX

As most of our readers probably know a very comprehensive index of engineering literature is compiled each month by the American Society of Mechanical Engineers and published in the Journal of that Society. These monthly indices are compiled into book form and published in annual volumes.

The Engineering Index is the continuation of a work started in 1884, when Prof. J. B. Johnson, of Washington University, St. Louis, began regularly to index for the Journal of the Association of Engineering Societies, the articles appearing in several of the leading periodicals of that time. Later (in 1895) this index was combined with a similar one that was being published by the Engineering Magazine Company. At the close of 1918, the American Society of Mechanical Engineers acquired the Engineering Index and the number of periodicals indexed was increased three-fold.

We have before us the Engineering Index of 1919 which unfortunately reached us too late to be reviewd in the July issue of the SCIENTIFIC AMERICAN MONTHLY. In this index, a change has been made in the arrangement of the subject matter. Heretofore, the items have been grouped under divisions of engineering, such as civil, electrical, mechanical, etc., but in the present volume the alphabetical or dictionary arrangement has been employed. Each item contains the exact title of the articles indexed, the author's name if given, the name of the periodical in which the article appeared, the volume number, and the page numbers and number of figures in the article. Each item concludes with a brief note summarizing the article indexed, and there are numerous cross references, which enable one to confine his search to the articles which bear directly upon his problem.

The index for 1919 comprises 528 pages and contains over 12,000 items referring to articles in nearly 700 engineering and allied technical journals, both foreign and domestic.

$5,000 Prize Essay

The Einstein Theory of Relativity

Mr. Eugene Higgins offers through the SCIENTIFIC AMERICAN a prize of $5,000 for the best essay on the Einstein theories so written that it may be read with profit by an ordinarily intelligent person with no special mathematical training. The competition is open to any person, without restrictions of any sort, subject to the following

Conditions:

1. No essays shall be longer than 3,000 words.

2. All essays must be in English, and written as simply, lucidly and non-technically as possible.

3. Each essay must be typewritten, and identified with a pseudonym. The essay shall bear a title and the author's pseudonym *only*, and must be enclosed in a plain sealed envelope likewise bearing this pseudonym. In the same package with the essay must be sent a second plain sealed envelope, also labelled with the pseudonym, and containing a statement of the name and address of the contestant, the pseudonym used, and the title of the essay. It is necessary to follow these instructions implicitly, in order to guard against confusion in opening the envelopes and assigning the pseudonyms to their proprietors, especially in view of the possibility that two of the contestants may employ the same pseudonym. The envelopes should be sent in a single package to the Einstein Prize Essay Editor, SCIENTIFIC AMERICAN, 233 Broadway, New York.

4. All essays must be in the office of the SCIENTIFIC AMERICAN by November 1st, 1920.

5. The Editor of the SCIENTIFIC AMERICAN will retain the small sealed envelopes containing the competitor's names and addresses, which will not be opened until the competitive essays have been passed upon and the winning essay selected.

6. As soon as the judges have selected the winning essay, they will notify the Editor, who will open the envelope bearing the proper pseudonym and revealing the competitor's true name. The competitor will at once be notified that he has won, and his essay will be published in an early issue of the SCIENTIFIC AMERICAN.

7. There shall be but one prize, of FIVE THOUSAND DOLLARS, to go to the author of the best essay submitted.

8. The SCIENTIFIC AMERICAN reserves the right to publish in its columns, or in those of the SCIENTIFIC AMERICAN MONTHLY, or in book form, any of the essays which may be deemed worthy of this. Aside from such rights, the essays shall remain the properties of their authors; but no manuscripts can be returned.

9. The Committee of Judges will consist of Professors Leigh Page, of Yale, and E. P. Adams, of Princeton. In the event that they are unable to agree on the best essay, the Einstein Prize Essay Editor will cast the deciding vote.